



AGRICULTURAL RESEARCH INSTITUTE

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The Meetings for Scientific Business are held in the Meeting Room at the Society's Office fortnightly on Tuesdays, except in July, August, September, and December and January, at half-past Five o'clock P.M.

The Anniversary Meeting is held on the 29th of April, or the nearest convenient day, at Four P.M.

The Society's Gardens are open daily from Nine o'clock until Sunset, or 8 P.M. when sunset is later. Dr. G. M. Ververs is the Superintendent, Mr. D. Seth-Smith, Curator of Mammals and Birds; Mr. Edward G. Boulenger is Director of the Aquarium; Miss Joan B. Procter, D.Sc., F.L.S., is Curator of Reptiles; Mr. L. C. Bushby, F.E.S., is Curator of Insects; Mr. S. Zuckerman, M.A., M.R.C.S., L.R.C.P., is Anatomist; Col. A. E. Hamerton, C.M.G., D.S.O., Pathologist. Prof. R. T. Leiper, F.R.S., with the assistance of a panel of experts, examines and reports on the Parasites; Prof. G. H. Wooldridge, F.R.C.V.S., is Honorary Consulting Veterinary Surgeon; Miss Ida C. Mann, D.Sc., M.B., B.S., F.R.C.S., is Honorary Consulting Ophthalmic Surgeon; and Dr. R. W. A. Schoond, O.B.E., Honorary Radiologist to the Society. Applications for anatomical or pathological material, or for facilities for work in the Prosectorium should be addressed to the Secretary.

TERMS FOR THE ADMISSION OF FELLOWS.

FELLOWS pay an Admission Fee of £5, and an Annual Contribution of £3, due on the 1st of January, and payable in advance, or a Composition of £45 in lieu thereof; the whole payment, including the Admission Fee, being £50.

No person can be deemed a FELLOW until the Admission Fee and first Annual Subscription of £3 have been paid, or the annual payments have been compounded for.

The usual Admission Fee of £5 is waived upon the election of the WIFE or HUSBAND of an existing FELLOW.

The First Annual Subscription of Fellows elected in November and December covers the following year.

PRIVILEGES OF FELLOWS.

FELLOWS have Personal Admission to the Gardens upon signing their names in the book at the entrance gate, and may introduce Two Companions daily.

The WIFE or HUSBAND of a FELLOW can exercise these privileges in the absence of the Fellow, but this privilege cannot be extended to children of Fellows.

Until further notice, FELLOWS, unless they have exercised the option stated in the next sentence receive each year 40 undated Green cards, available on any Sunday or week-day up to the end of January of the year following the year of issue, and 20 White cards available on any week-day up to the same date. For 20 Green tickets, however, they may receive a book of dated Sunday orders, each admitting two persons, but valid only for the actual days printed on them, and in exchange for twenty White tickets, a similar book of week-day orders, each valid only for the week printed on it. Special children's tickets are no longer issued, as the Green and White cards are perforated, and each half is valid for a Child under twelve years of age. Additional Sunday tickets cannot be purchased or acquired. It is particularly requested that Fellows *will sign every ticket* before it goes out of their possession. Unsigned tickets are not available.

FELLOWS are not allowed to pass in friends on their written order or on presentation of their visiting cards.

AQUARIUM. - FELLOWS have free personal admission to the Aquarium at all times when it is open. On Sundays, but not on week-days, they may introduce two visitors with them. These privileges are personal and cannot be transferred. The undated Green cards will give admission to the Aquarium to Visitors already in the Gardens, but two tickets will be needed for admission to Gardens and Aquarium. At the same time Fellows are reminded that whereas Aquarium tickets may be purchased it is not possible to obtain additional Sunday tickets giving Admission to the Gardens. For admission to the Aquarium of other friends whom they have admitted to the Gardens by Sunday tickets they may purchase from the Office books of 20 tickets for £1, or a smaller number at the same rate, each ticket admitting one adult or two children on Sundays or week-days. FELLOWS may also purchase a transferable AQUARIUM IVORY TICKET, for £10, valid for the whole duration of the Fellowship and admitting daily, on Sundays or week-days, two persons who have already gained admission to the Gardens.

WHIPSNADE ZOOLOGICAL PARK.—FELLOWS also have the right of personal admission to Whipsnade Park by signature at the Entrance, but this privilege is not transferable to WIFE or HUSBAND. The green tickets and the dated Sunday orders referred to above are also valid at Whipsnade Park, but the white tickets and week-day orders are not valid. Tickets valid on any day during the year of issue only may be purchased at 1s. each or six for 5s.

FELLOWS have the privilege of receiving the Society's ordinary Publications issued during the year upon payment of the additional Subscription of One Guinea. This Subscription is due upon the 1st of January, and must be paid before the day of the Anniversary Meeting, after which the privilege lapses. FELLOWS are likewise entitled to purchase these Publications at 16 $\frac{2}{3}$ (2d. in 1/-) per cent. less than the price charged to the public. A further reduction of 25 per cent. is also made upon all purchases of Publications issued prior to 1881, if above the value of Five Pounds.

FELLOWS also have the privilege of subscribing to the Annual Volume of 'The Zoological Record,' which gives a list of the Works and Publications relating to Zoology in each year, for the sum of Two Pounds Ten Shillings. Separate divisions of volumes 39 onwards can also be supplied. Full particulars of these publications can be had on application to the Secretary.

FELLOWS may obtain a TRANSFERABLE IVORY TICKET admitting two persons, available throughout the whole period of Fellowship, on payment of Ten Pounds in one sum. A second similar ticket may be obtained on payment of a further sum of Twenty Pounds.

Any FELLOW who intends to be absent from the United Kingdom during the space of at least one year, may, upon giving to the Secretary notice in *writing*, have his or her name placed upon the "dormant list," and will then be called upon to pay an annual subscription of £1 only during such absence, or in the event of returning to the United Kingdom before June 30th in any year to pay the balance of the ordinary subscription. After three years a Dormant Fellow must make a further application to be retained on that list.

Any FELLOW, having paid all fees due to the Society, is at liberty to withdraw his or her name upon giving notice in *writing* to the Secretary.

Ladies or Gentlemen wishing to become Fellows of the Society are requested to communicate with "The Secretary."

P. CHALMERS MITCHELL,

Secretary.

Regent's Park, London, N.W. 8.

June, 1931.

MEETINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON

FOR

SCIENTIFIC BUSINESS.

1931

TUESDAY, OCTOBER 20
 ——— NOVEMBER 3 and 17.

The Chair will be taken at half-past Five o'clock precisely.

ZOOLOGICAL SOCIETY OF LONDON.

LIST OF PUBLICATIONS.

THE scientific publications of the Zoological Society of London are of two kinds—"Proceedings," published in royal octavo form, and "Transactions," in quarto.

According to the present arrangements, the "Proceedings" contain not only notices of all business transacted at the scientific meetings, but also all the papers read at such meetings and recommended to be published in the "Proceedings" by the Committee of Publication. A large number of coloured plates and engravings are issued in the volumes of the "Proceedings," to illustrate the new or otherwise remarkable species of animals described therein. Amongst such illustrations, figures of the new or rare species acquired in a living state for the Society's Gardens are often given.

The "Proceedings" for each year are issued in four parts, paged consecutively, during the months of March, June, September, and December. From January 1901 they have been issued as two half-yearly volumes, indexed separately.

An "Abstract of the Proceedings" is published by the Society on the Tuesday following the date of the Scientific Meeting to which it refers. It is issued along with the "Proceedings," free of extra charge, to all Fellows who subscribe to the Publications, but it may be obtained on the day of publication at the price of Sixpence, or, if desired, sent post free for the sum of Six Shillings per annum, payable in advance.

The "Transactions" contain such of the communications made to the Scientific Meetings of the Society as, on account of the nature of the plates required to illustrate them, are better adapted for publication in the quarto form. They are issued at irregular intervals.

Fellows and Corresponding Members, upon payment of a Subscription of One Guinea *before* the day of the Anniversary Meeting, are entitled to receive the Society's Publications for the year. They are likewise entitled to purchase the Publications of the Society at 16½ per cent. (2*d.* in 1/-) less than the price charged to the Public. A further reduction of 25 per cent. is made upon purchases of Publications issued prior to 1881, if they exceed the value of Five Pounds.

Fellows also have the privilege of subscribing to the Zoological Record for a sum of Two Pounds Ten Shillings (which includes cost of delivery), payable on the 1st of July in each year; but this privilege is forfeited unless the subscription be paid *before* the 1st of December following.

The following is a complete list of the publications of the Society already issued.

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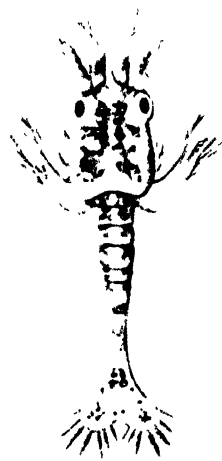
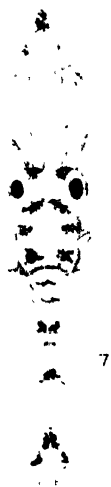
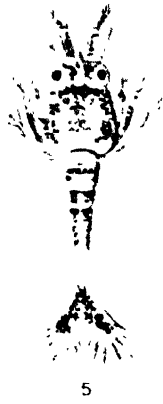
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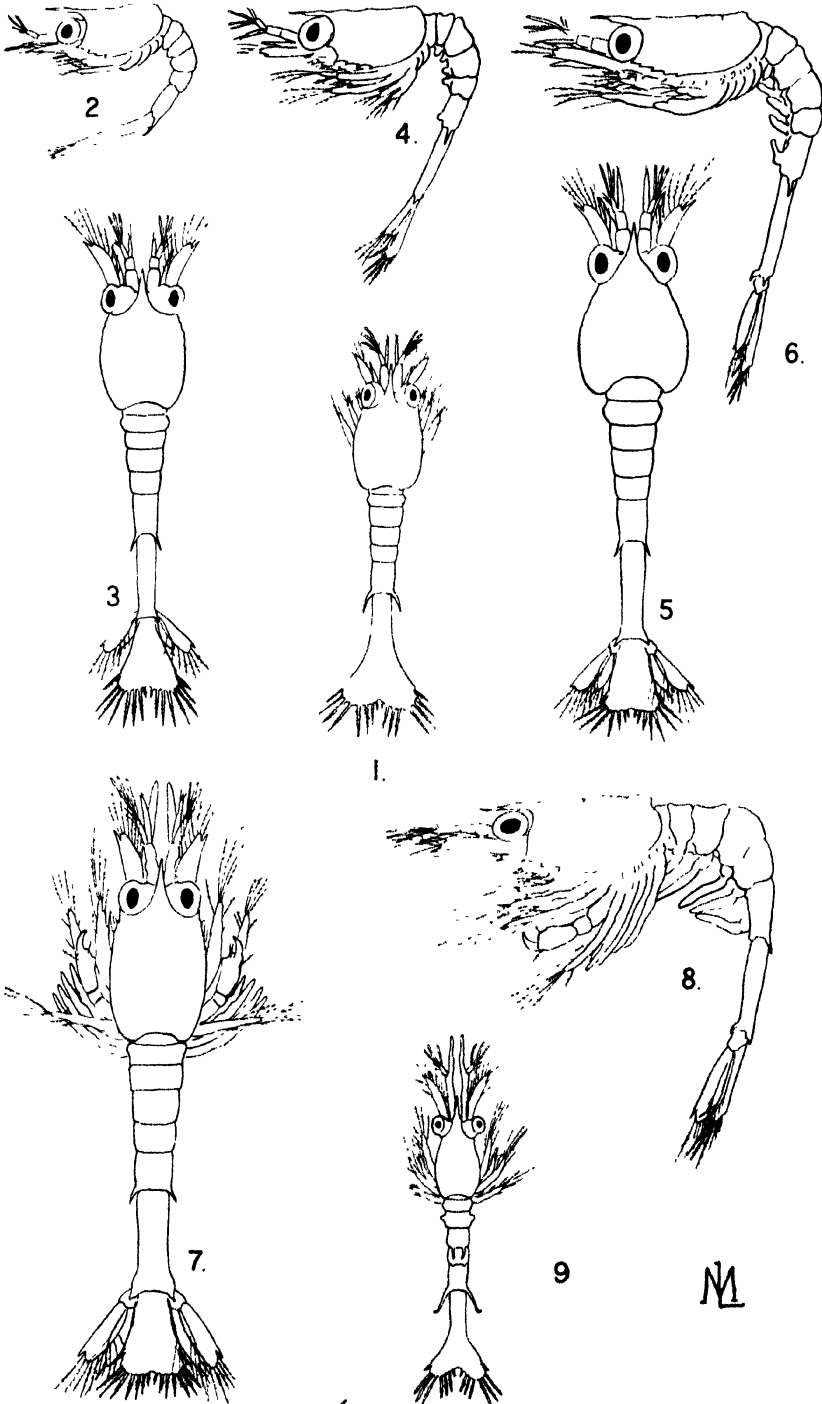
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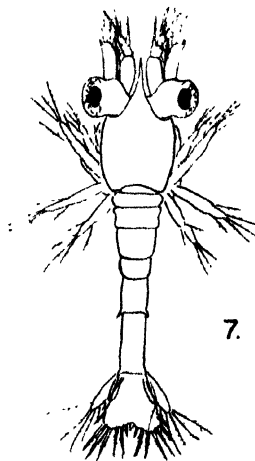
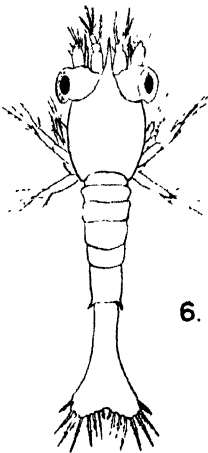
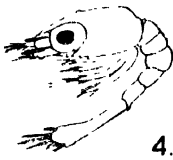
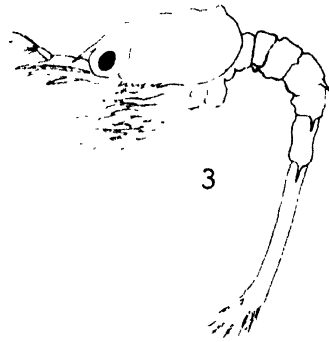
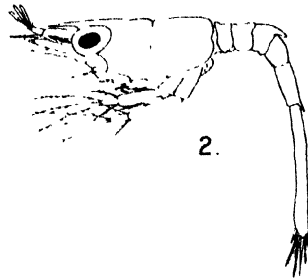
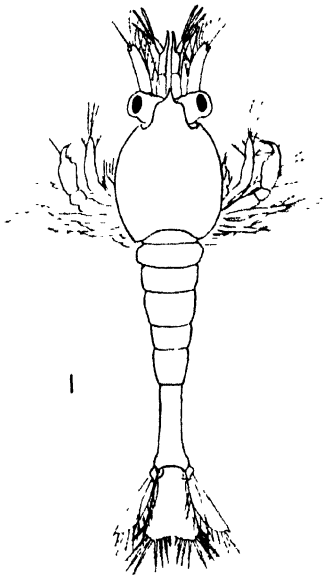
June, 1931.

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PROCEEDINGS
OF THE
GENERAL MEETINGS FOR SCIENTIFIC BUSINESS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.

PAPERS.

1. The Larvæ of the Plymouth Caridea.—I. The Larvæ of the Crangonidæ. II. The Larvæ of the Hippolytidæ. By MARIE V. LEBOUR, D.Sc., F.Z.S., Naturalist at the Plymouth Laboratory.

Received September 24, 1930 · Read February 3, 1931.]

(Plates I.—III.*)

I.—The Larvæ of the Crangonidæ.

There are seven members of the family Crangonidæ to be found at Plymouth, belonging to three genera—*Crangon* (two), *Philocheras* (four), and *Pontophilus* (one) :—

Crangon vulgaris (L.).
Crangon allmanni Kinahan.
Philocheras sculptus (Bell).
Philocheras fasciatus (Risso).
Philocheras trispinosus (Hailstone).
Philocheras bispinosus (Hailstone & Westwood).
Pontophilus spinosus Leach.

The larvæ of all but *P. sculptus* are already known, and this has now been recognized, making the list of larvæ complete. Several workers have written about them : G. O. Sars (1890), who described the larvæ of *Crangon vulgaris* and *C. allmanni*, *Philocheras bispinosus* (as *Ceraphilus nanus*), and *Pontophilus spinosus*, besides other crangonid larvæ not found in Plymouth ; Dr. R. Gurney (1903 a and b), who described the larvæ of *Philocheras fasciatus* and *P. trispinosus* (as *Egeon*), and gave tables showing the relationships of the various

* For explanation of the Plates, see p. 9.

larvæ, in a later paper (1923) comparing the characters of larval Crangonidæ with other closely-related families; and Miss G. E. Webb (1921), who distinguished between most of the crangonid larvæ of Plymouth. Besides the above, there are larvæ described by earlier naturalists which are attributable to species of *Crangon* or to its close relatives. Sars (*op. cit.*) cites Spence Bate (1888), probably a species of *Crangon*, and Claus (1861), probably *Philocheras* (as *Ceraphilus*). Gurney (1903 b) cites Claus (1884), probably *Philocheras trispinosus* (as *Ægeon*). Williamson (1901) describes the larvæ of *Crangon vulgaris* and (1910) the first stage of *Philocheras trispinosus* (as *Crangon*). From the work of Sars and Gurney we have a good idea of the larval Crangonidæ and of the differences between *Crangon*, *Philocheras*, and *Pontophilus*.

During the last few years it has been possible to hatch out in the laboratory nearly all the Plymouth species, including *Philocheras sculptus*, so far undescribed, and to follow out again most of the life-histories. The results show close agreement with the authors quoted, with the exception of *Crangon allmanni*, which, when obtained from the egg and in its early stages, has a large curved spine on each side of the fifth abdominal segment. As Sars specially states that the spines are very small in this species, it is important to note this difference between British and Norwegian forms. In the Plymouth specimens the size of the spines gradually dwindles, but in no case were they so small and inconspicuous as they are in Sars's figure of the last stage. A comparison of the larvæ of *Philocheras* now that *P. sculptus* is known shows that this species is the largest of our Plymouth forms and that it agrees with *P. hispinosus* in the position of the abdominal spines (and also with *P. echinulatus* (= *Ceraphilus*), described by Sars), *P. fasciatus* differing largely in general form and in the dwindling of the spines in the fourth segment, and *P. trispinosus* differing in the absence of any abdominal spines or, in rare cases, in the presence of small spines on the fifth segment. The colouring of all the larvæ hatched was carefully noted, and a coloured figure of the newly-hatched larva is given of all the species, with the exception of *Philocheras fasciatus* and of *Pontophilus spinosus*. These are all drawn to scale. The larvæ of *Pontophilus spinosus* are well known, and differ much from *Crangon* and *Philocheras*, so that it is impossible to mistake them. Figures and descriptions of this species are here omitted, also details of the appendages of *Crangon* and *Philocheras*, which are well described and figured by Sars.

THE LARVÆ OF THE CRANGONIDÆ.

The general characters of the larvæ of the Crangonidæ are the following:—

Five larval stages, the fifth changing to a young form like the parent.

No dorsal or supra-orbital spines on carapace.

The ventral anterior margins usually denticulate.

Rostrum usually narrow in the first stage, dwindling gradually to a point; in later stages usually broad at base, always conspicuous.

Telson indented slightly at the hind margin, becoming nearly straight in most forms in the later stages.

Abdomen usually with a pair of lateral spines on the fifth segment, third segment with or without central spine or lateral spines, fourth segment with or without lateral spines.

Antennule with the inner branch a straight spinous process in early stage. Stem usually rather short and thick.

Antennal scale unjointed in all stages. Endopodite a thick rod at first, swollen at the base.

First maxilla without an outer seat on the basipodite. Palp one- or two-jointed.

Second maxilla with a fourth internal lobe.

Three pairs of maxillipedes functional, with swimming-exopodites and jointed endopodites.

First leg rudimentary in first to third stages, with swimming-exopodite in fourth and fifth stages.

Second leg with or without exopodite, only showing in fourth and fifth stages.

Third, fourth, and fifth legs always without exopodite.

Pleopods developed as minute knobs in third stage, longer in fourth stage, jointed in fifth stage.

Anal spine developed in fourth stage.

The first three stages agree with all the Caridea known (except in those with precocious development), the first stage having sessile eyes, the telson a simple plate fused with the sixth abdominal segment and armed with seven pairs of spines at the end (except in a few foreign forms which may be neglected here); the second stage has stalked eyes and a pair of extra spines on the telson; the third stage with uropods developed and the telson cut off from the sixth abdominal segment. In this third stage the inner branch of the uropods has no setæ, or only one or two, whilst in the fourth stage it has several. The two outer spines on each side of the telson are ciliated on the inner border only, the others on both borders. The species of *Crangon* and *Philocheras* in all those seen at Plymouth also agree generally with the Caridea, as noted by Gurney, in having the pre-larval skin with six embryonic spines on the telson, the two inner spines on each side being covered by the same envelope.

THE LARVÆ OF *CRANGON*.

Two species occur at Plymouth, *Crangon vulgaris* and *Crangon allmanni*. Of these, *Crangon vulgaris* is an inshore form breeding in early spring through the summer in the inshore waters, and only rarely found outside, *C. allmanni* being a deeper-water form, breeding from early spring to early summer. The larvæ are seldom found together, and in spring the prevailing form inshore is *C. vulgaris*; the prevailing outside form is *C. allmanni*. Both are very common in the plankton. Sars has distinguished well between the two larvæ, which are easily differentiated.

Common Features of the Genus Crangon.

Fairly large larvæ (2 mm. to 2.8 mm. in the first stage, 4.7 mm. to 6.5 mm. in the last stage). The fifth abdominal segment with lateral spines; no lateral spines on the other segments. The third segment with or without a central spine. The carapace with lateral denticulations. The hind margin of the telson slightly indented. The rostrum evenly pointed, not very wide at the base, reaching as far as, or nearly to the end of, the base of the antennules. Dense coloration, yellow and brown or yellow and crimson. Second leg without an exopodite. First maxilla with one-jointed palp.

CRANGON VULGARIS (L.). (Pl. I. fig. 1; Pl. III. fig. 2.)

Colour yellow and brown, very dense. First larva *ca.* 2 mm. long, last larva *ca.* 4.7 mm. Eggs 0.56 mm. by 0.40 mm. Third abdominal segment

with a large central spine overlapping the fourth segment. Lateral spines on fifth segment of moderate size. Hatched from the egg in spring and summer. Larvæ in inshore plankton in all stages from spring to autumn.

CRANGON ALLMANI Kinahan. (Pl. I. fig. 2 ; Pl. II. figs. 1-8.)

Colour yellow and crimson, the crimson usually very conspicuous on the front ventral surface of the abdomen, telson, antennules, thorax, and in front of the eyes. First larva *ca.* 2.8 mm., last *ca.* 6.5 mm. Eggs 0.80 mm. by 0.48 mm. Third abdominal segment without a spine. Lateral spines on the fifth abdominal segment very long and curved in the first stage, gradually dwindling and becoming straight in the fourth and fifth stages. The earliest of the Crangonidæ in this district, beginning to breed in January. Hatched from the egg in spring. Larvæ in plankton in all stages; early stages from January to June, later stages through spring and summer. Rostrum longer than in *C. vulgaris*.

Common Features of the Genus Philocheras.

Larvæ in first stage 1.3 mm. to 2.16 mm. The fifth abdominal segment with lateral spines (except in *P. trispinosus*, when they are usually absent), the third and fourth segments also usually with paired spines, dorsal or dorso-lateral. Carapace with or without lateral denticulations. The hind margin of the telson more indented than in *Crangon*. The rostrum not so long as in *Crangon*, with a broad base, in later stages abruptly narrowing to a point. Dense coloration, usually red, brown, and yellow, the red, tending to be purple, predominating. An exopodite on the second legs in the later stages. The first maxilla with a two-jointed palp.

PHILOCHERAS SCULPTUS (Bell). (Pl. I. fig 3 ; Pl. III. fig. 3.)

The largest of the *Philocheras* species; the larvæ described here for the first time. First larva *ca.* 2.16 mm. Colour a pale diffuse yellow with dark purplish crimson, tending to be brownish, on the antennules, in front of the eyes, on the thorax dorsally and ventrally, in front of the first abdominal segment forming a band, and on the other abdominal segments; three chromatophores anteriorly on the telson. The rostrum reaches to about half-way to the end of the base of the antennules, pointed and rather broad: the carapace denticulated laterally. Dorso-lateral spines on the fourth, lateral spines on the fifth abdominal segments, pointed and fairly long: the third segment with shorter dorso-lateral spines; very small dorso-lateral knobs or spines sometimes on the second segment. Hatched from the egg in July. Adult rather rare in deeper water. Later larvæ not seen.

PHILOCHERAS FASCIATUS (Risso). (Pl. II. fig. 9.)

This larva has been described by Gurney (1903 *a* and *b*) and hatched from the egg by him. The larvæ occur in all stages in the plankton in summer, the adults being recorded fairly frequently from inshore. So far I have not hatched the larvæ myself, but have seen several in the inshore plankton.

First larva 1.8 to 2.05 mm. long, average 2 mm.; last stage 3.5 mm. to *ca.* 3.8 mm. (Gurney). Colour deep yellow, especially ventrally, with very dark brown, almost black, chromatophores, with a little purple, the dark brown on the antennules, in front of the eyes, all along the ventral part of the thorax and abdomen and on the telson, the whole animal being very dark, unlike any other crangonid larva in the district. Antennules with long peduncle.

Carapace not denticulated laterally. Rostrum not reaching to half the length of the antennular peduncles. The third abdominal segment with two conspicuous dorso-lateral spines, curved at the tips, the fourth with two dorsal spines or knobs, the fifth with a pair of long, curved, and very blunt lateral spines. The spines are in much the same position as they are in *P. sculptus*, but differ in form. Spines on the telson blunt.

This larva is so distinctive that it is not possible for it to be confounded with any other.

PHILOCHERAS TRISPINOSUS (Hailstone). (Pl. I. fig. 4 ; Pl. III. fig. 1.)

This larva has already been described by Gurney (1903 *a* and *b*), and I have also hatched it from the egg in July. Eggs 0.64 mm. by 0.4 mm. It is probably the most advanced of the *Philocheras* species, having lost its abdominal spines (except in rare cases mentioned by Gurney, in which the lateral spines on the fifth abdominal segment do occur, but are very small). The first larva measures 1.8 mm. to 2 mm., average length 1.9 mm. (Gurney), the last larva *ca.* 4.6 mm. Colour, according to Gurney, "light greenish yellow with a conspicuous branching chromatophore placed dorsally in the middle of the thorax." Those hatched out by myself at Plymouth had a very conspicuous magenta-red and brown colour on the top of the greenish yellow, the red occurring on the base of the antennules, antennal scales, in front of the eyes, and on the thorax with brown, and all along the abdomen mixed with brown. The antennular peduncle is fairly long, but not so long as in *P. fasciatus*, the inner branch having cilia, but not spines. The rostrum reaches to half the length of the antennular peduncle. The antennal scale fairly narrow. The carapace not denticulated at the antero-ventral margin. No spines on the abdominal segments except, occasionally, on the fifth, as mentioned above.

The adult is fairly common inside and outside the Sound. Larvæ in the plankton in late spring and throughout the summer.

PHILOCHERAS BISPINOSUS (Hailstone & Westwood). (Pl. I. fig. 5.)

Larvæ described by Sars (*op. cit.*) as *Ceraphilus nanus*. Hatched from the egg at Plymouth. Egg 0.48 mm. by 0.32 mm. when ready to hatch. Larva very like that of *P. trispinosus*, but smaller and with spines on the third, fourth, and fifth abdominal segments and denticulations on the ventral margin of the carapace. First larva 1.3 mm. long, last *ca.* 3.5 mm. The antennular peduncle fairly long, the inner branch covered with spines at the tip. The rostrum short, not reaching half-way up the peduncle. Very small spines dorso-laterally on the third abdominal segment, laterally on the fourth and fifth. In the later stages the rostrum is very broad at the base and curves up to the pointed apex. Colouring much like that of *P. trispinosus*, but brighter, the yellow foundation bright, with magenta and dark brown chromatophores on the antennule, in front of the eyes, on the thorax, maxillipides, abdomen, and telson. On the telson the brown becomes almost black. The adult is common inshore at Plymouth, breeding in spring and summer. Larvæ in the plankton fairly common in spring and summer.

On comparing these four *Philocheras* larvæ we find that, except in *Philocheras fasciatus*, they agree in the nature of the colouring, which is like *Crangon allmanni*, but not so like *C. vulgaris*, also in having exopodites on the second legs, *Crangon* having them only on the first pair. The *Philocheras* larvæ agree in having a short rostrum, not reaching more than half-way up the antennular peduncle, the latter being long, and in having paired spines laterally

or dorso-laterally on the third, fourth, and fifth abdominal segments, except in *P. trispinosus*, which appears to have lost these recently. The hind margin of the telson is more indented than in *Crangon*. As Sars has already shown, there is a one-jointed palp on the first maxilla in *Crangon*, whilst it is two-jointed in *Philocheras*; also shown by Gurney in *P. fasciatus*. It is to be noted that the Scandinavian species *Philocheras echinulatus* (described by Sars as *Ceraphilus*), also found off the Irish coast, is very like *P. sculptus*, *P. fasciatus*, and *P. bispinosus* in its larva, having paired spines on the third, fourth, and fifth abdominal segments.

Gurney (1903 a) gives a key to the species of Crangonidæ. The present key is based on his, but somewhat altered, and applies only to the species of *Crangon* and *Philocheras* found at Plymouth.

Key to the Species of Crangon and Philocheras Larvæ found at Plymouth.

- I. Larvæ with paired spines on fifth segment only.
 - First maxilla with one-jointed palp. Exopodite in later stages on first leg only
 1. 3rd abdominal segment with central spine *Crangon*.
 2. 3rd abdominal segment without central spine *Crangon vulgaris*.
 3. 3rd abdominal segment without central spine *Crangon allmanni*.
- II. Larvæ without central spine on third abdominal segment. First maxilla with two-jointed palp. Exopodites in later stages on first and second legs
 1. No lateral spines on third and fourth abdominal segments: sometimes very small spines on fifth segment, disappearing in later stages. No denticulations laterally on carapace *Philocheras*.
 2. Lateral spines on third, fourth, and fifth abdominal segments.
 - a. Spines of fifth abdominal segment long and curved, blunt spines on telson. No denticulations laterally on carapace *Philocheras trispinosus*.
 - b. Spines on abdominal segments pointed. Denticulations laterally on carapace.
 - ×. Larvæ large, over 2 mm. in first stage *Philocheras fasciatus*.
 - × ×. Larvæ small, first larva ca. 1·3 mm. in first stage *Philocheras sculptus*.
 - Philocheras bispinosus*.

II.—The Larvæ of the Hippolytidæ.

Two species of *Hippolyte* are recognized from this area—*Hippolyte varians* Leach and *Hippolyte prideauxiana* Leach (= *Hippolyte viridis* Heller). The *Hippolyte fascigera* of Gosse, which is also abundant, is now usually regarded as synonymous with *H. varians*. It occurs most commonly inshore, but is occasionally found on the outside grounds near the Eddystone. Its structure, except for the characteristic tufts of feathery setæ, seems to be identical with *H. varians*, although its colour is always different, being usually a mottled sandy shade. On hatching the eggs in the Laboratory, it was found that the larvæ were indistinguishable in structure from those of *H. varians*, although sometimes the colouring was more like *H. prideauxiana*. It is here regarded as a distinct variety of *H. varians*.

The structure of the larvæ of *Hippolyte* is well known from the work of Sars (1911), who describes the larval stages of *H. varians* and the appendages in detail. Miss Webb (1921) figures the first larva of this species from Plymouth. Gurney (1923) gives the characters of the Hippolytidæ in a table comparing certain closely-related families of the Caridea. These characters are chiefly based on *Hippolyte varians*, with a few references to *Spirontocaris*. (It is hoped to describe the larvæ of *Spirontocaris cranchii* in a later paper, as it differs considerably from *Hippolyte*.) In all the literature noted above the larva of *Hippolyte varians* is described as having no lateral spines on the fifth abdominal segment, whilst they are present in all the Plymouth specimens seen by me. Moreover, in the known larvæ of the other species of *Hippolyte* they are also

present. Gurney (1927, p. 272) describes the complete larval history of *Hippolyte orientalis* from Kabret (Cambridge Expedition to the Suez Canal). This agrees in all essentials with the two *Hippolyte* species from Plymouth. We now know the larvæ of three species and one variety of *Hippolyte*—*H. varians* and var. *fascigera*, *H. prideauxiana* and *H. orientalis*—and all these agree in essential features. We therefore may describe confidently the generic characters of the larval *Hippolyte*. On the other hand, the family Hippolytidae is at present composed of a variety of forms with very different larvæ. I have recently shown (1930) that the larvæ of *Caridion*, usually placed in the family Hippolytidae, are much more like those of *Pandalus* than *Hippolyte*; those of *Spirontocaris*, so far as they are at present known, are like *Hippolyte* in certain ways, but in others quite different; also the larvæ of *Lysemata seticaudata*, described by Caroli (1918), differ much from *Hippolyte*. On the whole, it seems that from their larval characters the Hippolytidae as at present recognized should be split up into several families.

The generic characters of *Hippolyte* may be thus summarised:—

Five larval stages (four only actually found by Gurney in *H. orientalis*), the last changing to a post-larva slightly different from the adult. Rostrum distinct, narrow, and pointed, slightly enlarged at base. Carapace with anterior lateral denticulations. Median tubercle behind rostrum. Telson with hind margin slightly indented or almost straight, the plate itself becoming narrower in the last stage. No spines on first to fourth abdominal segments. Small lateral spine on the fifth segment. The antennules with a short, stout stem, the inner branch represented by a seta in the first stage. The antenna with the scale jointed at the tip in the early stages (the joints hardly showing in *H. orientalis*). The endopodite is a rod swollen at the base with one terminal spine or seta. The first maxillæ with an outer seta on the base and an unjointed palp. The second maxillæ with four lobes. The first larva with the usual three maxillipedes with swimming exopodites and jointed endopodites. Legs one and two are rudimentary buds in the first stage. All the legs developing gradually. The first four larval stages as is usual in the Caridea. The first with eyes covered by the carapace, the sixth abdominal segment fused with the telson, the telson with seven spines on each side, the two outer spines ciliated on the inside only, the others on both sides. The second stage with stalked eyes, the telson as before, but with an extra pair of spines internal to the others. The third stage with the sixth abdominal segment separate from the telson; uropods present, but not cut off from their base and no setæ on the inner branch. The fourth stage with the base cut off from the uropods and setæ on both branches. Exopodites on the first and second legs in the later stages. The first pair of legs with swimming exopodite in the third stage. The fifth stage changing to the post-larva. An anal spine present in the fourth stage. Pleopods as minute buds in the third stage, larger in the fourth, long in the fifth. Gills present in last stage.

HIPPOLYTE VARIANS Leach. (Pl. I. fig. 6; Pl. III. fig. 4.)

The larvæ and appendages are fully described by Sars (1911). The first stage figured by Miss Webb (1921).

Neither of these workers describes or figures the spines on the fifth abdominal segment. They are also stated to be absent by Gurney (1927, p. 272). Of the many larvæ examined from Plymouth by myself, both hatched from the egg and collected from the plankton, all have these spines, although they may be small. They are also present in the larvæ of var. *fascigera*, in *H. prideauxiana*, and in *H. orientalis*. We may therefore take this to be a general

character of the genus, possibly dwindling to disappearance in the Norwegian form.

Five larval stages. Young hatched from the egg in July. Egg 0.40 mm. by 0.28 mm. Embryonic cuticle cast before hatching; the embryonic telson with six spines, as is usual in the Caridea. Colour: yellowish to orange chromatophores on thorax, in front of eyes, on base of antennules, on abdominal segments, and on telson, mixed with dark brown. The yellow may become orange, and some of the plankton specimens are much brighter than those hatched from the egg.

Adult very common inshore. Breeding chiefly in summer. Larvæ in inshore plankton in summer. First larva *ca.* 1.26 mm. long, sometimes slightly longer. The carapace with two or three denticulations laterally. The rostrum fairly conspicuous, pointed. The fifth abdominal segment with short lateral spines. The telson slightly indented at the centre of the hind margin.

Var. *FASCIGERA* (= *Hippolyte fascigera* Gosse) occurs with the type in Cawsand Bay and other inshore localities. Also occasionally in deeper water outside, from the Eddystone and Mewstone grounds. The larvæ hatched from the inshore specimens were very like those of *varians* in colour and size, and it was not possible to distinguish them, but those from outside gave rise to larvæ slightly larger and with colouring more like those of *H. prideauxiana*. Both, however, had the structure of *varians*.

HIPPOLYTE PRIDEAUXIANA Leach. (Pl. I. fig. 7; Pl. III. figs. 5-7.)

Larvæ described here for the first time. Adult fairly common in Plymouth Sound. Larvæ in inshore plankton in summer, hatched from the egg in June. Eggs 0.56 mm. by 0.30 mm. Embryonic cuticle as in *H. varians*. Colour dull yellowish with very dark brown chromatophores on thorax, in front of eyes, on abdomen, and on telson, mixed with a little dark red; dark yellow on third maxillipede. First larva 1.6 mm. long. The rostrum rather larger than in *H. varians*. The carapace with four or five lateral spines. Abdominal spines on fifth segment fairly large. The telson very slightly indented on the hind margin. Second larva from first 1.71 mm. long; third larva from second 1.71 mm. long. These larvæ were reared in a small glass bowl, the water changed every day, and small, fresh plankton added for food. Although the size is the same in the second and third stages, the structure is different, and the third stage is typical of all the third stages in the Caridea, with jointed antennular peduncle, no joints on antennal scales, and the outer setæ gone; the first leg with swimming-exopodite, the sixth abdominal segment cut off from the telson and uropods formed, although there are as yet no setæ on the inner branch. Later stages not seen.

LITERATURE CITED.

- BATE, C. SPENCE. 1888. Report on the Crustacea Macrura collected during the 'Challenger' Expedition, pp. 1-942.
- CAROLI, E. 1918. *Miersia clavigera* Chun, Stadio misidiforme di *Lyemata seticaudata*. Pubbl. Staz. Zool. Napoli, ii. p. 177.
- CLAUS, C. 1861. Zur Kenntniss der Malacostracenlarven. Würzb. Naturwiss. Zeits. ii. pp. 23-46.
- CLAUS, C. 1884. Zur Kenntniss der Kreislauforgane der Schizopoden und Decapoden. Arb. Zool. Inst. Wien, v. pp. 271-318.
- GURNEY, R. 1903 a. The Larvæ of Certain British Crangonidæ. Journ. Mar. Biol. Assoc. n. s. vi. no. 4, pp. 595-597.

- GURNEY, R. 1903 b. The Metamorphosis of the Decapod Crustaceans *Ægeon* (*Crangon*) *fasciatus* Risso and *Ægeon* (*Crangon*) *trispinosus* (Hailstone). Proc. Zool. Soc. Lond. 1903, pp. 24-30.
- GURNEY, R. 1923. Larval Stages of *Processa canaliculata* Leach. Journ. Mar. Biol. Assoc. n. s. xiii. no. 1, Dec. 1923, pp. 245-265.
- GURNEY, R. 1927. Report on the Larvæ of Crustacea Decapoda: Cambridge Expedition to the Suez Canal, 1924. Trans. Zool. Soc. part 2, 1927, pp. 231-286.
- LEBOUR, M. V. 1930. The Larval Stages of *Caradion*, with a Description of a new species. *C. stereni*. Proc. Zool. Soc. Lond. 1930, part 1, May, pp. 181-194.
- SARS, G. O. 1890. Bidrag til Kundskaben om Decapodernes Forvandlinger. III. Fam. Crangonidae. Arch. Math. Naturw. Bd. xiv. pp. 132-195.
- SARS, G. O. 1911. Account of the Postembryonal Development of *Hippolyte varians* Leach. Archiv for Math. Naturw. Bd. xxxii. no. 7, pp. 1-25.
- WEBB, G. E. 1921. The Larvæ of the Decapoda Macrura and Anamura of Plymouth. Journ. Mar. Biol. Assoc. n. s. v., xii. no. 3, May 1921, pp. 386-417.
- WILLIAMSON, H. C. 1901. On the Larval Stages of Decapod Crustacea. The Shrimp: *Crangon vulgaris* Fabr. 19th Ann. Rep. Fish. Board Scotland, part iii. pp. 92-119.
- WILLIAMSON, H. C. 1910. Report on the Larval and Later Stages of *Portunus holsatus*, etc. Fisheries Scotland, Sci. Invest. 1909 (Dec. 1910), London, 1911, pp. 1-20.
- WILLIAMSON, H. C. 1915. Decapoden. I. Teil (Larven). Nordisches Plankton, ii. Kiel und Leipzig, pp. 1-587.

EXPLANATION OF THE PLATES.

(The figures are drawn to two scales, scale A being twice the size of B.)

PLATE I. (coloured) Newly-hatched larvæ from egg (Scale A).

- Fig. 1. *Crangon vulgaris*, 2 mm. long.
 2. *Crangon allmanni*, 2·8 mm. long.
 3. *Philocheirus sculptus*, 2·16 mm. long.
 4. *Philocheirus trispinosus*, 1·8 mm. long.
 5. *Philocheirus trispinosus*, 1·3 mm. long.
 6. *Hippolyte varians*, 1·26 mm. long.
 7. *Hippolyte prideauxiana*, 1·6 mm. long.

PLATE II. (scale B).

Figs. 1-8. *Crangon allmanni*, from plankton.

- Fig. 1. Second larva, dorsal view, 3·3 mm. long.
 2. The same, side view.
 3. Third larva, dorsal view, 4·2 mm. long.
 4. The same, side view.
 5. Fourth larva, dorsal view, 4·8 mm. long.
 6. The same, side view.
 7. Fifth larva, dorsal view, 6·5 mm. long.
 8. The same, side view.
 9. *Philocheirus fasciatus*, second larva, 3·27 mm. long

PLATE III.

Fig. 1, scale B; figs. 2-7, scale A.

- Fig. 1. Fifth (last) larva of *Philocheirus trispinosus*, length 4·3 mm.
 2. *Crangon vulgaris*, side view, first larva.
 3. *Philocheirus sculptus*, side view, first larva.
 4. *Hippolyte varians*, first larva, side view, from egg.

Figs. 5-7. *Hippolyte prideauxiana*.

5. First larva, side view, from egg.
 6. Second larva, from first, 1·80 mm. long.
 7. Third larva, from second, 1·80 mm. long.

2. The Osmotic Concentration of the Blood of *Callorhynchus millii* and *Epiceratodus (Neoceratodus) forsteri*, and the Significance of the Physico-chemical Condition of the Blood in regard to the Systematic Position of the Holocephali and the Dipnoi. By WILLIAM J. DAKIN, D.Sc., F.Z.S., Challis Professor of Zoology, University of Sydney.

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Several years ago I commenced a series of investigations on the physical and chemical relationship of the internal fluids of aquatic animals and the water forming their environment. Perhaps it was unfortunate that two of the most important papers which resulted from these earlier investigations were published in journals not likely to be read by English-speaking zoologists (2 and 4). Indeed, very little on this subject has appeared in English journals until quite recently, and it is only now that some of the most striking features of aquatic invertebrates and vertebrates are becoming generally known*. Yet 48 years have elapsed since Fredericq (6) commenced his studies on the internal fluids of aquatic animals, and 33 years since Botazzi (1) noted the remarkable differences between the blood of Elasmobranch and Teleost fishes.

The internal fluids—the blood, coelomic fluid, etc.—of aquatic animals are separated from the external medium—the water bathing their bodies—by membranes which may be impermeable to water and salts, semipermeable, or readily permeable to both water and salts. The last-mentioned condition does not seem to occur in nature under normal conditions. The living membranes, which permit of interchange between organism and environment, have more the character of semipermeable membranes, which are almost impermeable to salts in solution, but more or less readily permeable to water. It is easy to show that in many cases the bounding membranes act physically like characteristic dead semipermeable membranes (such as parchment). Thus a marine worm or a starfish placed in a more concentrated sea water commences at once to lose weight, due to loss of water by osmosis, whilst conversely in a diluted sea water it swells up and its weight increases.

But complication is added by the fact that the bounding membranes of the living organism are—either all or some—alive; the constitution of the internal medium may be varied as a result of metabolic change. Furthermore, there are special excretory mechanisms which exercise a control over the constitution of the internal fluids. The relations existing between the internal medium and the external medium are, consequently, the result of a complex of factors, and it is significant to note that, as one passes from the lower invertebrates to the higher vertebrates, we pass to more complex conditions; so it may be said that there is a gradual evolution of a constancy in blood-constitution. The organs of the highest vertebrates function in an environment which is as constant in chemical constitution as it is in temperature.

Two methods have been utilized to investigate the relationships with which we are concerned—direct chemical analyses of the constitution of the blood, and freezing-point determinations from which the osmotic conditions can best be determined.

* At Hobart the Author was greatly aided through the kindness of Professor Flynn, of the University of Tasmania, and Mr. Clive Lord, of the Museum.

The results of many experiments divide the aquatic animals into the following groups :—

(a) *Aquatic Marine Invertebrates generally*.—The freezing-point of their blood is almost identical with that of the surrounding sea water, and there is a very close resemblance in the saline contents of both internal and external media. (i.) In the Echinoderms and worms there is almost perfect agreement between the salts of the internal fluids and the surrounding sea water. (ii.) In the higher crustacea the chlorine content of the blood is somewhat lower than that of the sea water.

(b) *Aquatic Freshwater Invertebrates* (molluscs and crustacea).—The salinity is more or less greater than that of the surrounding medium, and the freezing-point is consequently lower. In the case of decapod crustacea (crayfish) the salinity and freezing-point of the blood are considerably different from the salinity and freezing-point of the water in which they live.

(c) *Teleost Fishes in Sea Water or in Fresh Water*.—The salinity and freezing-point of blood are relatively constant, and in the case of marine species the salinity is very different from that of the ocean water in which they may be living.

(d) *Elasmobranch Fishes in Sea Water*.—The freezing-point of their blood is almost the same as that of the sea water bathing their bodies, and in this respect they appear at first sight like the marine invertebrates, but the salinity of the blood is quite different from that of the sea water. The low freezing-point and its agreement with the freezing-point of the external medium is due to relatively enormous quantities of urea in the blood of these animals. In this respect the Elasmobranchs are unique.

The conditions enumerated above may be illustrated by the following figures from actual observations :—

| Animal. | Surrounding medium. | Salinity of surrounding medium. | Freezing-point of surrounding medium. | Salinity of blood. | Freezing-point of blood. |
|--|---------------------|---------------------------------|---------------------------------------|--------------------|--------------------------|
| <i>Holacrus cordiformis</i> | Sea water | *Approx. 3.0 ‰ | -1.89° C. | 2.49 | -1.79° C. |
| European crayfish <i>Astacopsis</i> | Fresh water " " | Practically nil. " | 0.2° C. 0.0° C. | 1.11 | -0.80° C. -1.045° C. |
| <i>Pleuronectes platessa</i> | Sea water | *Approx. 3.5 ‰ | -1.95° C. | 0.9 | -0.8° C. |
| <i>Cyprinus carpio</i> | Fresh water | 0 ‰ | 0° C. | 0.63 | -0.53° C. |
| <i>Abramis brama</i> | " " | 0 ‰ | 0° C. | . | -0.51° C. |
| <i>Scyllium canicula</i> .. | Sea water | *Approx. 3.5 ‰ | -2.0° C. | 1.6 ‰ | -2.15° C. |

* The term Approx. is used because the chlorine analysis represents the tests on the samples of sea water bottled at the time the specimens were taken.

In order to determine how the physio-chemical conditions noted above are related to changes in the chemical constitution of the sea water or fresh water, several investigators have tried the effect of diluting sea water with fresh water or of adding salts to normal sea water, or of modifying fresh water. Such experiments have permitted us to learn much, but one grave criticism is applicable to many of them—the changes have been made too quickly to permit of adaptation. This is particularly the case when investigating the dependence or independence of Teleost body-fluids, and it was for this reason

that I went to such trouble to obtain Teleosts from a naturally varying environment by travelling from the less saline Baltic Sea to the North Sea (3) *. The results of all such work may be summed up as follows :—

(a) The Teleost fishes have evolved a constancy of blood constitution—a controlled salinity which is almost, but not quite, independent of changes in the surrounding sea water. This constancy of blood-salinity is met with in all the higher vertebrates.

(b) The blood constitution of marine invertebrates (more especially non-arthropod groups), so far as salts are concerned, seems almost entirely dependent upon the salinity of the surrounding sea water. In the Decapod crustacea this dependence lies only within certain limits, and it would be difficult to separate this class of aquatic animals from the following one.

(c) Freshwater invertebrates seem much less dependent upon the salinity of the external medium than their marine relations, for generally the blood contains an appreciable quantity of salts and the freezing-point is much lower than that of the water surrounding them.

(d) Freezing-point determinations show that the blood of Elasmobranch fishes is osmotically dependent upon the salinity of the sea water. Under normal conditions the blood and the sea water in which the fish are living are almost isotonic. (Actually the freezing-point of the blood appears in general to be slightly lower than that of the sea water.) The freezing-point of the blood closely follows changes in the freezing-point of the external medium.

The following figures from my paper (3) on the Baltic-North Sea conditions indicate the degree of change met with under normal conditions :—
Teleostii.

| | | Freezing-point. Sea Water. | Freezing-point. Blood. |
|---------------------------------|--------------------------|-------------------------------|---------------------------|
| <i>Pleuronectes platessa</i> .. | Baltic Sea | —1·01° C | —0·65° C. |
| " " " .. | North Sea | —1·9° | —0·78° |
| <i>Anguilla vulgaris</i> | Fresh water | 0° | —0·57° |
| " " " .. | Sea water at Heligoland. | —1·9° | —0·63° |

Elasmobranchii.

| | | | |
|---------------------------|------------------|--------|-------|
| <i>Raia radiata</i> | Baltic Sea | —1·66° | —1·7° |
| " <i>valonia</i> | North Sea | —1·98° | —2·0° |

By keeping Elasmobranchs (*Acanthias vulgaris*) in fresh water, I have brought the freezing-point of the blood up to —1·45° in three hours. These fish were, however, in a dying condition. It still remains to determine the blood conditions in those Elasmobranchs which live in practically fresh water.

It is the Elasmobranch conditions that formed the starting-point for the work described in this paper. The Elasmobranch conditions are so unique that an isolated heart of a dogfish cannot be kept alive and beating in an ordinary physiological saline solution like Ringer's solution. One must make up a saline containing up to 2·5 per cent. of urea !

These conditions so impressed me that for years I have taught First Year Medicine students that the Elasmobranchs are chemically and physiologically quite apart from the rest of the fishes, and as distinct from the higher vertebrates. One might say with justice that it is misleading to group Teleosts

* The French worker Duval (5) has recently published papers on the osmotic pressure of teleost blood without, apparently, being aware of any of the experiments recorded in my publications (2, 3, and 4).

and Elasmobranchs together as Pisces. And with these ideas in mind it has always seemed particularly desirous to investigate the blood of the Holocephali* and the Dipnoi. Little or nothing is known of the physiology of these two groups of fish-like organisms.

Unfortunately, specimens of both groups are not easily obtainable in the living condition—particularly in the proximity of a laboratory, and I have always deemed it essential to work with living fish and fish taken from their natural environment. For many years I waited for the opportunity of investigating the blood of *Chimæra monstrosa*, which is now caught in considerable numbers by the deep-sea trawlers off S.W. Ireland, but without success. Last year I was informed that at certain seasons *Callorhynchus millii* is captured off the southern coast of Tasmania. I travelled, therefore, to Hobart in December, and was able to obtain a number of living specimens and to carry out the necessary analyses.

The Holocephali are generally regarded to-day as an order of Elasmobranch fishes, although certain authorities have elevated them to the rank of a subclass, with affinities to the Dipnoi. They present affinities to the Elasmobranchs in their scales, skeleton of cartilage with absence of membrane bones, fin-skeleton and claspers, urinogenital organs, and certain features in the brain, etc. They also lay large eggs of quite a typical Elasmobranch character. On the other hand, they differ from the Elasmobranchs in having an autostylic skull and in their vertebral column, also in their teeth, the presence of an operculum, and in having only four branchial clefts.

In view of what has been said above of the unique physiological conditions prevailing in the typical Elasmobranchs, it might be expected that the examination of Holocephali blood would give strong evidence of the systematic position of the group—and might reveal small or large physiological differences from both Elasmobranchs and Teleosts, just as there are morphological differences.

CALLORHYNCHUS MILLII.

The freezing-point of the blood of *Callorhynchus* was determined by means of a Beckman apparatus in the usual manner. Other samples of the blood were analyzed for both urea and chlorides. Urea was estimated by the urease method (Van Slyke (8, 10)). In view of inaccuracies which had been discovered by testing control urea solutions, the potency of the urease extracts was carefully investigated and controls were used with urea solutions. Chlorine was estimated by the method of Van Slyke (9) for blood analysis. It must be noted that for both chlorine and urea analyses in blood of the Elasmobranch type very different amounts of reagents are required compared with the amounts generally used for vertebrate blood. The results of the analysis were quite definite:—

Freezing-point of blood of Callorhynchus.

Several determinations gave average $\Delta = -1.76$.

Δ of sea water (several samples) = -1.5 to -1.85 .

(It was not possible to determine the constitution of the sea water in which the fish had been living more closely than the above figures owing to variations in the salinity of the bottom and middle depth water at the place where they were caught.)

* The only reference to the Holocephali in the literature on this subject occurs in a paper by Krukenburg in 1888. Krukenburg (7) detected urea in the alcohol in which specimens of *Chimæra* had been kept. At that time, however, the actual physical conditions of the Elasmobranch blood were unknown, and their differences from the Teleosts were scarcely realized.

Urea content of blood (several analyses) :

2.4 to 2.86 per cent.

Chlorine content of blood :

Equivalent to 1.33 per cent. of NaCl.

It will be noted that the urea content is as high as that found for the blood of typical Elasmobranchs—a figure quite different from that for the blood of any vertebrate from the Teleostei to the Primates. The chlorides are also typically Elasmobranch in amount (higher than characterizes the typical aquatic vertebrate of the higher groups, including the Teleostei; lower than that of marine invertebrates). The freezing-point of the blood is not far removed from that of the sea water in which the animals had been living. There can be no doubt whatever from these figures that the *Holocephali* are typical *Elasmobranchs*—a specialised subdivision, but one showing no indications (so far as the relation with which we are concerned) of a transition to Dipnoi or Teleostei. The data confirm the conclusion that the Elasmobranchs stand out as a very specialized offshoot of the vertebrate phylum.

DIPNOI.

To make observations on the Dipnoi, *Ceratodus* (*Epiceratodus forsteri*) was chosen as the example, and once again it turned out to be necessary to travel to the country where the animal is found in nature in order to obtain live specimens. On this occasion two large specimens were obtained (thanks to the great kindness of Dr. Bancroft, of Eidsvold, Queensland) from the Burnett River, and forwarded to Brisbane. The fish were met at Brisbane, transferred to tanks in the Queensland Museum, and the analyses carried out at that place*.

No observations have been made of the blood composition of any of the Dipnoi, and I am hoping not only to extend the few new recorded, but to arrange for certain other physiological work on these interesting animals in the near future.

Freezing-point of blood of Epiceratodus forsteri.

The Δ of the blood was -0.42°C .

It will be noted that the freezing-point of the blood is typical of that of the Teleosts and higher aquatic vertebrates.

The chlorine analyses which were made on other samples gave the following result :—

Chlorine equivalent to NaCl in blood..... 0.45 per cent.

It may be noted in passing that the depression of the freezing-point, i.e., the Δ of mammalian blood, is about 0.56° to 0.6°C . The lower figure is equal to a 0.9 per cent. solution of NaCl. The freezing-point of the blood of the frog as an amphibian example has been recorded as about -0.43°C ., and the normal saline for frog tissues is equivalent to 0.65 per cent. NaCl solution. The freshwater Teleostei for which some of my own data are available give blood freezing-points as follows :—

| | | |
|---|-------|----------------------------|
| <i>Anguilla vulgaris</i> , from fresh water | | -0.570°C . |
| <i>Cyprinus carpio</i> | „ „ | -0.530 |
| <i>Abramis brama</i> | „ „ | -0.51 |

* I am greatly indebted to Dr. Bancroft for the specimens, and to Mr. H. A. Longman, of the Queensland Museum, for his kindness in placing a working space in the museum at my disposal.

The freezing-point of *Ceratodus* blood is, on the whole, rather high compared with the records available for even the freshwater Teleostei, and the salinity (on the low side) is also in accord with this. It is possibly worthy of note, therefore, that the freezing-point of amphibian blood (so far as records from the frog are concerned) is also on the high side—considerably higher than mammalian blood—and that the salinity is correspondingly lower. Some of the records for Teleost blood are certainly not far removed from those obtained from *Ceratodus*, but it must be remarked that, on the whole, there is a peculiar coincidence in the similarity between the *Ceratodus* figures and those usually accepted for the frog. At the time the analyses were made, a few blood-smears were also taken. It is not a new discovery, but it is worth repeating that the red blood corpuscles of *Ceratodus* are also remarkably amphibian-like and of large size.

SUMMARY.

The osmotic pressure and the salinity of the blood of *Callorhynchus antarcticus* and of *Epiceratodus forsteri* have been investigated with a view to determining the relations between internal fluids and the aquatic environment in the Holocephali, and the Dipnoi.

Live fish were examined, and the specimens were quite normal (the *Callorhynchus* were examined at Hobart, Tasmania, and the *Neoceratodus* at Brisbane, Queensland).

The blood of the *Callorhynchus* had a freezing-point almost the same as the sea water in which the specimens were living. The blood contained over 2.6 per cent. urea and chlorine representing 1.33 per cent. NaCl.

These figures indicate that *Callorhynchus* presents the extraordinary conditions found in only one group of the animal kingdom—the Elasmobranchii.

The blood of *Epiceratodus* has a relatively high freezing-point, $-0.42^{\circ}\text{C}.$, compared with -0.5 to 0.6 for freshwater Teleostei, and -56 to -0.6 for mammalia. There is no resemblance whatever to Elasmobranch conditions. The Dipnoi fall into the same category as the higher vertebrates. The freezing-point of the blood is curiously like that of the amphibia.

List of Literature.

- (1) BOTAZZI. La Pression Osmotique du Sang des Animaux marins. Arch. Ital. de Biol. 1897.
- (2) DAKIN, W. J. Variations in the Osmotic Concentration of the Blood and Cerebral Fluid of Aquatic Animals, caused by changes in the external medium. Biochem. Journ. iii. 1908.
- (3) DAKIN, W. J. The Osmotic Concentration of the Blood of Fishes from Sea Water of naturally varying concentration. Biochem. Journ. 1907-8, iii.
- (4) DAKIN, W. J. Notes on the Biology of Fish-eggs and Larvæ. Internat. Revue der Ges. Hydrobiologie, Band iii. 1910-11.
- (5) DUVAL. Recherches physico-chimiques et physiologiques sur le milieu intérieur des animaux aquatiques. Ann. Des. Oceanog. n. s. 2, 1925.
- (6) FREDERICQ. Arch. de Zoologie expérimentale, 2 série, iii. 1885.
- (7) KRUKENBURG. Ann. du Mus. d'Hist. Nat. de Marseille, iii. 1888.
- (8) VAN SLYKE and CULLEN. Journ. Biol. Chem. 1914.
- (9) VAN SLYKE. Journ. Biol. Chem., Dec. 1923.
- (10) VAN SLYKE and FOLIN. Manual of Biol. Chem. New York, 1925.

3 A Contribution to the Knowledge of the Spider Fauna of South-West Ireland and, in particular, the Islands off the Coast. By W. S. BRISTOWE, B.A., F.Z.S.

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INTRODUCTION.

A short visit was paid to South-western Ireland in June 1929 primarily with the object of collecting spiders on the islands off the coast of Kerry so as to enable a comparison to be made with results obtained from Clare Island, farther north, and from the Scottish, Welsh, and English islands.* In addition, it was my object to make collections at various points on the mainland of Kerry to compare with the island faunas, and to climb one or two of the higher mountains. My actual itinerary was as follows:—

- June 21st. By car from Cork to Killarney.
- June 22nd. Ascent of Carrantual, 3414 ft. (highest mountain in Ireland); then to Glenbeigh for the night.
- June 23rd. Motored to Cahirciveen and crossed to Valentia Is.
- June 24th. By boat to the Skelligs, landing on St. Michael.
- June 25th. By boat to the Blaskets, landing on Inishvickillane.
- June 26th. Returning to mainland, motored to Darrynane, and crossed to Scarif Is. Back to Valentia.

* D. R. Pack Beresford: Clare Island Survey, Araneida. Proc. Roy. Ir. Acad. vol. xxxi. 1911.

W. S. Bristowe: The Spider Fauna of the Western Islands of Scotland. Scot. Nat. May-June and July-August, 1927.

" " The Spiders of the Scilly Islands. Proc. Zool. Soc. pt. 2, 1929.

" " The Spiders of Lundy Island. Proc. Zool. Soc. pt. 2, 1929.

" " A Contribution to the Knowledge of the Spiders of the Channel Islands. Proc. Zool. Soc. pt. 2, 1929.

" " The Spiders of Skomer Island (S. Wales). Proc. Zool. Soc. pt. 4, 1929.

- June 27th. Visits to Church Is. and Degenish Is.
 June 28th. Left Valentia and motored to Fenit.
 June 29th. Motored to Candiha and crossed to Illauntannig, one of the Magharee or Seven Hogs Is. Visited Carrahane sands in the evening before returning to Fenit.
 June 30th. Motored to Faha and ascended Brandon Mt., 3127 ft. Returned to Fenit.
 July 1st. Motored to Cork, stopping for a short time on the way near Derrynassagart Hills (close to Co. Cork boundary) and Macroom (Co. Cork).

98 species were collected, of which 6 were Phalangids and 1 a Chelifer. 52 species were found on the various islands. 21 for Kerry and 9 for Cork. 4 species are new records for Ireland*.

Some of my previous distributional and ecological observations received confirmation in Ireland :—

1. I showed recently that *Pholcus phalangioides* Fuess. had a distribution in the south of England only, and that its northern limits coincided with the 50° annual average temperature curve†. In Ireland the known records confirmed this, and search revealed it in Killarney, Glenbeigh, Valentia, Cahirciveen, and Darrynane.

2. *Tegenaria derhamii* Scop. was found in the lighthouse on the Skelligs, where it must have been transported by man, and from there, presumably, it had spread to a little cave on the same island. It was also present in the single houses which exist on Scarif and one of the Seven Hogs, and on the latter in a little shallow coast-cave as well. On Degenish, which is no longer inhabited, it was found in a little damp cave, showing that its liking for houses, with which it is usually associated, is on account of their subdued light and, perhaps, equable "climate" rather than their dryness.

3. *Zilla x-notata* Clerck, like *Pholcus* and *Tegenaria derhamii* Scop., is carried everywhere by man. At Cork and Fenit I saw its webs on railway trucks in use.

Recently, when I made a collection of spiders in London parks, and especially in Buckingham Palace garden, I found that, with the exception of *Zilla*, Epeirids like *E. diademata* and *Meta* were very scarce or entirely lacking, presumably on account of the smoky acid condition of shrubs. On one of the Magharee or Seven Hogs islands *Meta merianæ*, *Epeira diademata*, and the other Epeirids which were elsewhere abundant appeared to be entirely absent. As in the case of the London parks, this gives *Zilla* the chance to flourish without competition, and it was abundant on all shrubs, stone walls, etc.

4. Two of the predominant species in the Scilly Islands are *Drassodes lapidosus* Walck. and *Textrix denticulata* Oliv., but both frequent similar habitats, and I have suggested that the abundance of the latter varies to some extent inversely with that of the former, which is very fierce and does not appear to allow *Textrix* to inhabit the same crevices or stones. In Ireland I found *Textrix* to be more particularly abundant than usual on Degenish Island and on one of the Seven Hogs, where *Drassodes* was apparently absent.

* *Lepthyphantes whymperi* Camb., *Oreonetides vaginatus* Thor., *Centromerus concinnus* Thor., and *Porrhomma pallidum* Jacks.

† Proc. Zool. Soc. pt. 4, 1929.

5. In the Scilly Islands and Lundy I noted the scarcity of species in areas frequented by Puffins. One of the species which does not appear to share this distaste for these areas is *Lepthyphantes zimmermannii* Bertk., and on the Skelligs I found it in its little webs spun in the entrance of unoccupied puffin-holes.

6. *Agelena labyrinthica* Clerck does not occur on the Scilly Islands, Lundy, or Skomer, although it is common on the adjoining mainlands in each case within a short distance of the coast. In Ireland I found it at Cork, Macroom, Carrahane, and at Darrynane within 150 feet of the sea, yet it was apparently absent from all the islands. At Darrynane it was abundant, and I counted no fewer than eight webs on a single gorse-clump. I am a firm believer in the powers of dispersal of spiders, and I am inclined to believe, in spite of finding this species so close to the coast, that it has here reached its limit of tolerance of exposed conditions.

That there is some distinct climatic difference between the coastal strip of the mainland and the islands is clearly seen by the nature of the vegetation. Gorse, instead of being luxuriant, as at Darrynane for instance, if present at all, which is usually not the case, is thin and scraggy on the islands.

It would be interesting to introduce it into one of the islands to see whether it became established there.

7. *Tetragnatha extensa* Linn. is the only member of its genus which can support island conditions or is to be found in exposed areas near our coast, and it is to be found on all the chief islands round our coasts.

8. *Aeronautic Spiders*.—On June 28th a wall and posts near the sea at Fenit were swarming with aeronautic spiders embarking on flights. Those collected comprised the following species in the order of their apparent preponderance :—

| | | |
|------------------------------------|----|------------|
| <i>Erigone dentipalpis</i> | 17 | 3 |
| „ <i>atra</i> | 15 | 2 |
| <i>Edothorax fuscus</i> | 8 | |
| <i>Bathyphantes gracilis</i> | 2 | 3 |
| <i>Lepthyphantes tenuis</i> | 1 | 3 |
| <i>Erigone longipalpis</i> | 2 | |
| <i>Savignia frontata</i> | .. | 1 |
| Total..... | 45 | specimens. |

This analysis is in accordance with my previous observations on the dominant aeronautic species in England (Proc. Zool. Soc. pt. 4, 1929, p. 653).

9. Sandhills were visited at Glenbeigh, Darrynane, Fenit, Carrahane, and Degenish Island, but their spider fauna was very disappointing. The following species were found amongst Marram or other plants :—

| | |
|-------------------------------------|-----------------------|
| <i>Chubionæ</i> (immature)..... | Carrahane. |
| <i>Agræca</i> (immature) | Carrahane. |
| <i>Xysticus cristatus</i> | Fenit, under stones. |
| <i>Tibellus oblongus</i> | Carrahane. |
| <i>Enoplognatha thoracica</i> | Fenit, under stones. |
| <i>Theridion ovatum</i> | Carrahane, Degenish. |
| <i>Linyphia pusilla</i> | Glenbeigh, Carrahane. |

| | |
|---|--|
| <i>Lepthyphantes tenuis</i> | Glenbeigh, Carrahane, Fenit. |
| „ <i>mengei</i> | Glenbeigh. |
| „ <i>ericæus</i> | Carrahane. |
| <i>Stemonyphantes lineatus</i> | Carrahane. |
| <i>(Edothorax fuscus)</i> | Glenbeigh, Fenit, Degenish. |
| <i>Aræoncus humilis</i> | Glenbeigh. |
| <i>Erigone dentipalpis</i> | Fenit (abundant). |
| „ <i>atra</i> | Fenit (abundant). |
| <i>Ero furcata</i> (or <i>cambridgii</i>) (immature) | Carrahane. |
| <i>Tetragnatha extensa</i> | Glenbeigh. |
| <i>Trochosa picta</i> | Glenbeigh, Degenish. |
| „ <i>terricola</i> | Glenbeigh. |
| <i>Lycosa agricola</i> | Fenit, Degenish. |
| <i>Phalangium opilio</i> | Glenbeigh, Carrahane, Fenit, Degenish. |

Both on Degenish Is. and at Fenit *Lycosa agricola* extends on to the shore, and in the latter locality *Erigone dentipalpis* was found amongst washed up seaweed. On Illauntanzig, seaweed harboured three species of *Erigone*—*E. dentipalpis*, *E. atra*, and *E. arctica*.

At Glenbeigh, mud-flats adjoin the sandhills, and here amongst the plants, side by side with crabs and sandhoppers, were found *Erigone longipalpis*, *E. dentipalpis*, *(Edothorax fuscus)*, and *Lycosa monticola*, all in considerable numbers. This last species does not, as a rule, extend to mud-flats, although it is common near the coast, but is replaced by the very closely allied *L. purbeckensis* F. Camb.

10. Elsewhere I have given examples of spiders with communal webs, and of instances where spiders of the same or of different species have webs connecting with one another. At Darrynane I came across an interesting case of this. I threw a sandhopper into the web of an *Agelena labyrinthica* to see if it would appreciate this salt diet, and its struggles attracted not only the owner of the web, but also a *Theridion sisyphium*, whose flimsy snare was connected to the underside of the *Agelena*'s sheet-web. Whilst the *Agelena* was biting the sandhopper, the *Theridion* ran along the undersurface of the web, bit a small hole in it, and threw a few viscid strands of silk over the struggling crustacean. The *Agelena* then tugged in vain, for the sandhopper was securely anchored by these threads. It paused, and both spiders bit the sandhopper and partook of a short feast, which was interrupted by renewed activity on the part of the *Theridion*, which attempted to pull it through the hole it had made in the web. A tug-of-war ensued between the *Agelena* and the relatively minute *Theridion*. The former, finding it made no headway, took to shaking the web violently, and then, when this did not drive away the intruder, it launched an attack. The *Theridion* retreated half-way through the rent in the web, and kept it at bay by turning its back towards the *Agelena* and throwing viscid threads of silk at it with its hind legs. After further shakings of the web, the *Agelena* retreated and renewed its meal, but only for a few seconds, as this was the signal for further action on the part of the *Theridion*. The same sequence of events took place time after time, until finally the *Agelena* managed to drag the sandhopper away from the moorings laid by the *Theridion* and disappeared with it into its retreat, where the *Theridion* dared not follow. The struggle between these two very unevenly matched spiders had lasted a quarter of an hour.

11. It is a well-known fact that Lycosids which are deprived of their egg-bags will seize hold of and fasten to their spinnerets other objects of a suitable size *. On the Skelligs I removed a *Trochosa terricola*'s egg-bag. For a moment it appeared quite lost without it, and groped round in all directions until it happened to find a dry and somewhat bleached rabbit-dropping. This it seized in its jaws and, after fixing it to its spinnerets, trundled back to its shallow retreat in the ground, apparently quite oblivious of the mistake.

12. The spider fauna of the Kerry Islands resembles that of the southern English islands and also Clare Island fairly closely. Clare Island is apparently too far north for *Pholcus*, and, in addition, *Amaurobius fenestralis* and *A. ferox* are not recorded, but otherwise the dominant species are common to the Kerry Islands and to Clare Island.

Skelligs.

On June 24th a visit was paid to the Skelligs, which lie 16 miles off the coast. These islands are extremely attractive and very interesting. Skellig St. Michael, on which three or four hours were spent, is a pinnacle of black rock covered on one side almost completely with a soft green carpet of thrift, which was in flower at the time of my visit. The pinnacle, which must be about 500 feet in height, is ascended most easily by means of a stone stairway which leads to the well-preserved remains of a tiny chapel, bee-hive houses, and graveyard which is thought to be 1500 years old. This is situated just below the rocky peak.

Spiders are numerous, although species are few. The predominant species are :—

Segestria senoculata Linn.
Textrix denticulata Oliv.
Trochosa terricola Thor.

Drassodes lapidosus Walck.
Meta merianæ Scop.
Euophrys frontalis Walck.

In addition, the following species were collected :—

Dysdera crocata C. L. K.
Robertus lividus Bl.
Gongylidellum vivum Camb.
Lepthyphantes zimmermannii Bertk.
Tegenaria derhamii Scop.

D. erythrina Walck.
Ceratinella brevis Wid.
Bathypantes concolor Wid.
L. tenuis Bl.

It will be noted that all except *Meta merianæ* Scop. inhabit crevices, the roots of herbage, or the underside of stones. *Meta* built its webs across hollows in the rock-face on the sheltered side and in unoccupied puffin-burrows.

Apart from spiders, I noticed slugs, earthworms, snails (*Helix*), Thysanura, woodlice, two species of ant, and a wasp (*Odynerus*).

Blaskets.

On the following day an expedition was made to the Blaskets and a landing effected on Inishvickillane, which is a rounded, downy island with rugged cliffs. Sheep are grazed on this island, and there is evidence that at one time part was ploughed for cultivation. Rabbits are abundant, and shags and various

* Vide 'Irish Naturalist,' 1896, p. 299 : a large spider carrying a small bleached shell of *Helix virgata* containing its eggs under its body ; this was probably a *Trochosa* (or *Pisaura mirabilis*). Proc. Zool. Soc. 1926, p. 329 : *Lycosa palustris* (= *tarsalis*) carrying small snail-shell.

gulls breed on the less accessible parts of the island. *Textrix denticulata* was common under stones and in cracks in the rock-face. There it was joined in the less exposed positions by *Lepthyphantes zimmermannii* Bertk., which, with *Meta merianæ*, was also found in the entrances to disused rabbit-burrows. Under stones I found *Oonops pulcher* Templ., *Segestria senoculata* Linn., *Drassodes lapidosus* Walck., *Clubiona terrestris* Westr., *Amaurobius fenestralis* Stroem., *Trochosa terricola* Thor., *Euophrys frontalis* Walck., and the two Opilionids *Phalangium opilio* Linn. and *Nemastoma lugubre* O. F. M.

Amongst dwarf heather I found *Xysticus cristatus* Clerck, *Lepthyphantes ericæus* Bl., *Edothorax retusus* Westr., and *Paciloneta globosa* Wid. *Lycosa pullata* Clerck (some with eggs) were running in the sun, and *Salticus scenicus* Clerck, exploring the sheltered surface of a rock.

Scarif.

On Scarif, which was reached on June 26th by boat from Darrynane, the following species were collected :—

Segestria senoculata Linn.
Tegenaria derhamii Scop.
Lycosa pullata Clerck.
 „ *tarsalis* Thor.
Trochosa terricola Thor.
Pirata piratica Clerck.
Euophrys frontalis Walck.
Textrix denticulata Oliv.
Drassodes lapidosus Walck.

Clubiona neglecta Camb.
Enoplognatha thoracica Wid.
Lepthyphantes tenuis Bl.
Epeira diademata Clerck.
Meta merianæ Scop.
Tetragnatha extensa Linn.
Pachygnatha degeerii Sund.
Platybunus triangularis Herb.
Phalangium opilio Linn.

This island is mainly grassy. There is one house, in which *Tegenaria derhamii* was found, and a little stream beside which *Tetragnatha* and *Pirata* were collected. The island is too uniform in nature to support a great variety of species, and, compared with the mainland at Darrynane, the fauna seems very scanty.

Church and Degenish Islands.

About a quarter of an hour was spent on the tiny Church Island on June 27th before proceeding to Degenish. In addition to the ruins of a very ancient church, there is evidence of human habitation from very early times. Shell-middens, composed mainly of limpets, were found.

The only spiders I could find on Church Island were *Textrix denticulata* Oliv., *Segestria senoculata* Linn., *Tegenaria derhamii* Scop., *Amaurobius fenestralis* Stroem., and *Lepthyphantes tenuis* Bl.

Degenish Island is far larger, and some cultivation is still done. Along the low sheltered cliffs *Meta merianæ* Scop. is abundant, some being of the variety *celata*. Wherever shady hollows are present in these cliffs the webs of *Tegenaria derhamii* Scop. are to be seen. In one part ivy grows on the cliff-face, and amongst this *Amaurobius fenestralis* builds its webs. There are considerable expanses of sand, and here in the open or amongst plants *Trochosa picta* Hahn, *Theridion ovatum* Clerck, *Edothorax fuscus* Bl., and *Phalangium opilio* were collected. Amongst heaps of stones on the shore *Lycosa agricola* Thor. was abundant.

Other species collected were *Meta segmentata*, *Zilla x-notata* Clerck, *Theridion ovatum* Clerck, *Lepthyphantes tenuis* Bl., *L. mengii* Kulcz., *L. ericæus* Bl.

Magharee or Seven Hogs Is.

On June 29th I was rowed in one of the primitive tarred canvas canoes still in use in this part of Ireland out to the largest "Hog," which is named Illauntanzig. The island is low-lying and composed of limestone with a covering of sand. There is one house and some cultivation—mainly potatoes. Middens and ancient bee-hive house ruins testify to its having been inhabited from an early date.

The predominant spiders were *Zilla x-notata*, *Textrix denticulata* Oliv., *Amaurobius fenestralis* Stroem., *Trochosa terricola* Thor., and *T. ruricola* De Geer, three species of *Erigone*, and the Phalangid *Phalangium opilio* Linn. *Segestria senoculata* Linn. was not common, and *Meta merianæ* Scop. and *Drassodes lapidosus* Walck., which are predominant species on the other islands, apparently absent altogether.

Amongst seaweed and plants near the shore *Erigone arctica* White, *E. dentipalpis* Wid., and *E. atra* Bl. were all abundant.

Under stones amongst a small patch of luxuriant vegetation *Heliophanus cupreus* Walck. and *Clubiona lutescens* Westr. were both abundant in cells with their eggs and also in immature stages. The former have opaque white cells which contain the spider and about 30 yellow eggs; the latter have about 40 to 50 yellow eggs. In neither case are the eggs themselves protected by a layer of silk.

Other species were as follows :—

Tegenaria derhamii Scop., *Lepthyphantes tenuis* Bl., *Edothorax fuscus* Bl., *Arconcus humilis* Bl., *Savignia frontata* Bl.

13. *Carrantual and Brandon Mountains.*

On June 22nd I climbed Carrantual (3414 ft.), which is one of the M'Gillicuddy's Reeks and the highest mountain in Ireland, and on June 30th Brandon Mt. (3127 ft.). The last 1000 ft. of the former was enveloped in cloud, but fine weather was experienced for the ascent of Brandon. My records agree closely with the previously published ones that I have been able to find :—

Above 3000 feet.

Robertus lividus Bl. Carrantual and Brandon. Previously recorded from the summit of Carrantual *.

Oreonetides abnormis Bl. Carrantual and Brandon. Previously recorded from the summit of Carrantual *.

Oreonetides vaginatus Thor. Brandon.

Tapinopa longidens Wid. From 3000 ft. on M'Gillicuddy's Reeks *.

Lepthyphantes whymperi Cam. Carrantual.

Lepthyphantes zimmermannii Bertk. Carrantual and Brandon. Previously recorded up to 2500 ft. on "Kerry mountains" *.

Lepthyphantes pallidus Camb. From 3200 ft. on M'Gillicuddy's Reeks *.

Centromerus prudens Camb. Carrantual and Brandon. Previously recorded from 3000 ft. on M'Gillicuddy's Reeks *.

Centromerus bicolor Bl. Carrantual.

Centromerus concinnus Thor. Above 2000 ft. on Carrantual. Previously recorded at 3000 ft. from M'Gillicuddy's Reeks *.

Diplocephalus cristatus Bl. Brandon.

Erigone dentipalpis Wid. Brandon.

* Prof. G. Carpenter, Proc. R. I. Acad. 1898.

Hilaira frigida Thor. Brandon, above 3000 ft. ; Carrantual, between 1500 and 3000 ft.

Porrhomma pygmaeum Bl. Brandon. Previously recorded from 3000 ft. on M'Gillicuddy's Reeks *.

Porrhomma pallidum Jacks. Carrantual.

Leptorhoptrum huthwaitii Camb. From the summit of M'Gillicuddy's Reeks, over 3000 ft. *.

Trachynotus nudipalpis Westr. Between the base and 2000 ft. on Carrantual. Previously recorded from 3000 ft. on M'Gillicuddy's Reeks *.

Cryphaea silvicola C. L. K. Carrantual.

Lycosa pullata Clerck. One at 2800 ft. on Brandon ; on Carrantual below 2000 ft. Previously recorded from 3000 ft. on unspecified Kerry mountains *.

Nemastoma lugubre O. F. M. Carrantual above and Brandon below 3000 ft. Previously recorded from the summit of Carrantual †.

Mitopus morio Fabr. (= *Oligolophus alpinus*). Carrantual and Brandon. Previously recorded from the summit of Carrantual †.

Between 1500 and 3000 feet.

Of the species mentioned above, the following were also found on both mountains between 1500 and 3000 ft., and appeared, in fact, to be the dominant species right to the base :—

Robertus lividus Bl.

Oreonetides abnormis Bl.

Lepthyphantes zimmermanni Bertk.

Lycosa pullata Clerck.

Nemastoma lugubre O. F. M.

Mitopus morio Fabr.

In addition, there are the following to be noted :—

Lepthyphantes tenuis Bl. Below 2500 ft. on Carrantual and Brandon. Previously recorded in the mountains (Kerry not specified) up to 2000 ft. *.

Lepthyphantes ericæus Bl. Brandon, below 2000 ft.

Erigone promiscua Camb. Carrantual, below 1500 ft. Previously recorded from 1500 ft. on M'Gillicuddy's Reeks *.

Diplocephalus latifrons Camb. Recorded from 1500 ft. on M'Gillicuddy's Reeks *.

Agyneta (= *Microneta*) *subtilis* Camb. Recorded by D. Pack Beresford from Carrantual (Proc. Roy. Ir. Acad. 1909). Altitude not specified.

Diplocentria torrentum Kulcz. (= *Centromerus rivalis*). Brandon at 2000 ft.

Textrix denticulata Oliv. Up to 1500 ft. on both mountains. Previously recorded from 2000 ft. On unspecified Kerry mountains *.

Lycosa tarsalis Thor. (= *palustris*). Recorded from 2000 ft. on Brandon *.

Megabunus diadema Fabr. This Phalangid was not found above 1500 ft. on Carrantual or 2000 ft. on Brandon. One was eating a small Sciariid fly.

Three spiders and one Phalangid have been recorded from the summit of Mangerton ‡, a Kerry mountain with an altitude of 2750 ft., all of which were included in my collection from the summit of Carrantual and Brandon. These species are as follows :—

Robertus lividus Bl.

Oreonetides (= *Macrargus*) *abnormis* Bl.

Hilaira frigida Thor. (= *montigena*).

Mitopus morio Fabr. (= *Oligolophus alpinus*).

* Prof. G. Carpenter, Proc. R. I. Acad. 1898.

† Dr. Scharff and Prof. Carpenter, Irish Nat. 1899, p. 216.

‡ Irish Nat. 1910, p. 64.

In addition *Diplocentria torrentum* Kulcz. (= *Centromerus rivalis*), which I found on Brandon, and *Styloctetor morula* (= *S. uncinus*) have also been recorded from Mangerton some way below the summit*. The close agreement of my records with those of previous collectors appears to indicate that the spider fauna of the mountains of S.W. Ireland is now fairly well known.

I am much indebted to Mr. D. Pack Beresford for information relating to the recorded distribution of the species in my collection. In 1896 R. L. Praeger divided Ireland into botanical divisions which he called districts (Irish Nat. vol. v. p. 29). Many naturalists, including Mr. Pack Beresford himself, have adopted these districts for distribution purposes, so I have decided, in the following list of my captures, to mention not only where a species is recorded in Ireland, and in Kerry or Cork, for the first time, but also where they are new to one of Praeger's districts. Praeger divided Kerry into two districts, numbered 1 and 2, and Cork into three, numbered 3, 4, and 5 respectively. His map is a small-scale one, and the exact boundaries are therefore not always easy to determine, but the localities in which I collected appear to fall into these districts as follows:—

| | | | |
|------------|--------|-------------|--|
| Co. Kerry. | South. | District 1. | Carrantual Mt., Glenbeigh, Valentia Is., Skelligs, Blaskets, Darrynane, Scarif Is., Church Is., Degenish Is., Seven Hogs Is., Carrahane, Brandon Mt. |
| " | North. | " 2. | Killarney, Fenit, Derrynassagart. |
| Co. Cork. | West. | " 3. | Macroom (near). |
| " | Mid. | " 4. | Cork (near). |
| " | East. | " 5. | None. |

There appear to be 4 species new to Ireland, 21 new to Kerry, 9 new to Cork, and 51 additions to districts.

My sincere thanks are due to Dr. A. R. Jackson for examining the major portion of my collection.

List of Species collected in Kerry.

ARANEÆ (Spiders).

Fam. 1. OONOPIDÆ.

Oonops pulcher Templ. Blaskets, Killarney, Fenit. New to Kerry.

Fam. 2. DYSDERIDÆ.

Dysdera crocata C. L. K. Skelligs.
 " *erythrina* Walck. (imm.) Skelligs.
Segestria senoculata Linn. Skelligs, Blaskets, Scarif, Darrynane, Church Is., Seven Hogs Is.
Harpactes hombergii Scop. Killarney, in old Wren's nest.

Fam. 3. GNAPHOSIDÆ.

Drassodes lapidosus Walck. Skelligs, Blaskets Scarif. Specimens of enormous size.

* Irish Nat. 1899, p. 216.

Fam. 4. CLUBIONIDÆ.

| | |
|------------------------------------|---------------------------------|
| <i>Clubiona reclusa</i> Camb. | Glenbeigh, Killarney. |
| „ <i>terrestris</i> Westr. | Glenbeigh, Blaskets, Killarney. |
| „ <i>neglecta</i> Camb. | Scarif. |
| „ <i>lutescens</i> Westr. | Seven Hogs Is. |
| <i>Agræca</i> sp. (imm.) | Carrahane Sandhills. |

Fam. 5. THOMISIDÆ.

| | |
|--|------------------------------------|
| <i>Xysticus cristatus</i> Clerck | Darrynane, Blaskets, Fenit. |
| <i>Oxyptila trux</i> Bl. | Darrynane. |
| <i>Tibellus oblongus</i> Walck. | Carrahane Sandhills. New to Kerry. |

Fam. 6. DICTYNIDÆ.

| | |
|---|--|
| <i>Dictyna latens</i> Fabr. | Darrynane. |
| <i>Amaurobius fenestralis</i> Str. | Darrynane, Blaskets, Church Is., Degenish Is., Seven Hogs Is. |
| „ <i>similis</i> Bl. | Fenit. New to 2. |
| „ <i>ferox</i> Walck. | Killarney, Fenit. New to 2. |

Fam. 7. PHOLCIDÆ.

| | |
|--|--|
| <i>Pholcus phalangioides</i> Fuess. | Valentia Is., Cahirciveen, Glenbeigh, Darrynane, Killarney. New to 2. |
|--|--|

Fam. 8. THERIDIIDÆ.

| | |
|--|---|
| <i>Theridion sisypium</i> Clerck | Darrynane, Killarney, Derrynassagart. New to 2. |
| „ <i>varians</i> Hahn | Killarney. New to 2. |
| „ <i>ovatum</i> Clerck (= <i>T. lineatum</i>) | Valentia, Glenbeigh, Darrynane, Degenish Is., Carrahane Sandhills, Killarney. |
| „ <i>instabile</i> Camb. | Derrynassagart. New to Kerry. |
| <i>Enoplognatha thoracica</i> Hahn | Scarif, Fenit Sandhills, with up to three soft, round, white egg-cocoons containing 20-50 yellow eggs. New to 2. |
| <i>Robertus lividus</i> Bl. | Valentia, Skelligs. On Brandon Mt. above 3000 ft. and on Carrantual above 2000 ft. |

Fam. 9. LINYPHIDÆ.

| | |
|---|--|
| <i>Linyphia triangularis</i> Clerck | Darrynane. |
| „ <i>pusilla</i> Sund. | Glenbeigh, Darrynane, Carrahane Sandhills. |
| „ <i>clathrata</i> Sund. | Darrynane. |
| <i>Stemonyphantes lineatus</i> Linn. | Carrahane Sandhills. New to Kerry. |
| <i>Lepthyphantes tenuis</i> Bl. | Glenbeigh, Carrahane, Skelligs, Scarif, Church Is., Degenish, Seven Hogs Is., Brandon Mt., Carrantual, Fenit, Derrynassagart. |

| | |
|--|---|
| <i>Lepthyphantes zimmermannii</i> Bertk. . | Skelligs, Blaskets, Brandon Mt., Carrantual, Derrynassagart. New to 2. Previously recorded from Valentia. |
| „ <i>mengei</i> Kulcz. | Glenbeigh, Degenish Is. New to Kerry. |
| „ <i>ericæus</i> B.. | Valentia, Carrahane, Degenish Is., Blaskets, Brandon Mt., Killarney, Derrynassagart. New to Kerry. |
| „ <i>alacris</i> Bl. | Derrynassagart. New to Kerry. |
| „ <i>whymperi</i> Camb. | Carrantual, above 2000 ft. New to Ireland. |
| <i>Bathypantes gracilis</i> Bl. | Darrynane, Fenit. New to 2. |
| „ <i>concolor</i> Wid. | Skelligs. |
| <i>Pæciloneta globosa</i> Wid. | Blaskets. |
| <i>Ceratinella brevis</i> Wid. | Skelligs. New to Kerry. |
| <i>Gongylidiellum vivum</i> Camb. | Skelligs. New to Kerry. |
| <i>Oreonetides abnormis</i> Bl. | Brandon Mt., Carrantual Mt. |
| „ <i>vaginatus</i> Thor. | Brandon Mt. New to Ireland. |
| <i>Centromerus bicolor</i> Bl. | Carrantual. |
| „ <i>prudens</i> Camb. | Brandon Mt., Carrantual Mt. |
| „ <i>concinus</i> Thor. | Carrantual. New to Ireland. |
| <i>Erigone dentipalpis</i> Wid. | Glenbeigh, Seven Hogs Is., Brandon, Fenit. |
| „ <i>atra</i> Bl. | Seven Hogs Is., Fenit. New to 2. |
| „ <i>arctica</i> White | Seven Hogs Is. |
| „ <i>promiscus</i> Camb. | Carrantual. |
| „ <i>longipalpis</i> Sund. | Glenbeigh, Fenit. New to 2. |
| <i>Diplocephalus cristatus</i> Bl. | Brandon Mt. New to Kerry. |
| <i>Savignia frontata</i> Bl. | Seven Hogs Is., Fenit. |
| <i>Wideria antica</i> Wid. | Derrynassagart. New to Kerry. |
| <i>Trachynotus nudipalpis</i> Westr. | Carrantual. |
| <i>Dismodicus bifrons</i> Bl. | Valentia. |
| <i>Diplocentria torrentum</i> Kulcz. (= <i>Centromerus rivalis</i> Camb.). | Brandon Mt. |
| <i>Edothorax fuscus</i> Bl. | Glenbeigh, Degenish Is., Seven Hogs Is., Fenit. New to 2. |
| „ <i>retusus</i> Westr. | Blaskets. |
| <i>Aræoncus humilis</i> Bl. | Glenbeigh, Seven Hogs Is. New to Kerry. |
| <i>Porrhomma pygmæum</i> Bl. | Brandon Mt. |
| „ <i>pallidum</i> Jacks. | Carrantual Mt. New to Ireland. |
| <i>Hilaria frigida</i> Thor. | Brandon Mt., Carrantual Mt. |
| <i>Maso sundevallii</i> Westr. | Derrynassagart. New to 2. |

Fam. 10. MIMETIDÆ.

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|--|------------|
| <i>Ero furcata</i> Vill. or <i>cambridgei</i> Kulcz. (imm.). | Carrahane. |
|--|------------|

Fam. 11. ARGIOPIDÆ.

| | |
|--------------------------------------|---|
| <i>Epeira diademata</i> Clerck | Glenbeigh, Valentia Darrynane, Carrahane, Scarif. |
| „ <i>cucurbitina</i> Clerck | Glenbeigh. |

| | |
|--|---|
| <i>Zilla x-notata</i> Clerck | Glenbeigh, Valentia, Degenish Is., Seven Hogs Is., Darrynane, Fenit. |
| <i>Meta merianæ</i> Scop. | Degenish Is., (incl. var. <i>celeta</i>), Carran- tual, Carrahane, Scarif, Blaskets, Skelligs. |
| „ <i>segmentata</i> Clerck | Valentia, Degenish Is., Darrynane, Killarney. |
| <i>Tetragnatha extensa</i> Linn. | Glenbeigh, Valentia, Darrynane, Blas- kets, Scarif, Derrynassagart. |
| <i>Pachygnatha degeerii</i> Sund. | Valentia, Darrynane, Scarif. |

Fam. 12. AGELENIDÆ.

| | |
|--|--|
| <i>Agelena labyrinthica</i> Clerck | Darrynane, Carrahane. |
| <i>Tegenaria derhamii</i> Scop. | Degenish Is., Church Is., Scarif, Skel- ligs, Seven Hogs Is., Fenit. New to Kerry. |
| „ <i>atrica</i> C. L. K. | Fenit. New to Kerry. |
| <i>Textrix denticulata</i> Oliv. | Killarney, Degenish Is., Church Is., Scarif, Darrynane, Blaskets, Skelligs, Seven Hogs Is. |
| <i>Cryphæa silvicola</i> C. L. K. | Carrantual. |
| ? <i>Antistea elegans</i> C. L. K. (imm.) | Carrantual. |

Fam. 13. PISAURIDÆ.

| | |
|--------------------------------------|------------|
| <i>Pisaura mirabilis</i> Clerck | Darrynane. |
|--------------------------------------|------------|

Fam. 14. LYCOSIDÆ.

| | |
|---|--|
| <i>Lycosa pullata</i> Clerck | Valentia, Darrynane, Carrahane, Scarif, Blaskets, Brandon Mt., Carrantual, Derrynassagart. New to 2. |
| „ <i>amentata</i> Clerck | Darrynane. |
| „ <i>nigriceps</i> Thor. | Darrynane. |
| „ <i>monticola</i> C. L. K. | Glenbeigh. New to Kerry. |
| „ <i>tarsalis</i> Thor. (= <i>L. palustris</i> Linn.). | Scarif. New to 1. |
| <i>Trochosa terricola</i> Thor. | Glenbeigh, Scarif, Blaskets, Skelligs, Seven Hogs Is. |
| „ <i>ruricola</i> De Geer. | Seven Hogs Is. |
| „ <i>picta</i> Hahn | Glenbeigh, Degenish Is. |
| <i>Pirata piratica</i> Clerck | Darrynane, Scarif. |

Fam. 15. ATTIDÆ.

| | |
|--|-----------------------------|
| <i>Salicinus scenicus</i> Clerck | Blaskets. New to Kerry. |
| <i>Euophrys frontalis</i> Walck. | Blaskets, Skelligs, Scarif. |
| <i>Heliophanus cupreus</i> Walck. | Darrynane, Seven Hogs Is. |

PHALANGIDEA (Harvest Spiders).

| | |
|-------------------------------------|---|
| <i>Phalangium opilio</i> Latr. | Glenbeigh, Carrahane, Degenish Is., Scarif, Blaskets, Darrynane, Seven Hogs Is., Fenit. New to 2. |
| <i>Mitopus morio</i> Fabr. | Brandon Mt., Carrantual Mt. |

| | |
|---|---|
| <i>Platybunus triangularis</i> Herb. | Scarif. |
| <i>Liobunum blackwallii</i> Meade | Valentia, Darrynane. |
| <i>Megabunus diadema</i> Fabr. | Brandon Mt., Carrantual Mt. |
| <i>Nemastoma lugubre</i> Müll. | Darrynane, Carrahane, Blaskets, Brandon Mt., Carrantual Mt., Killarney. |

CHERNETIDEA (Pseudo-scorpions).

| | |
|-------------------------------------|---|
| <i>Obisium muscorum</i> Leach | Killarney, amongst dead leaves in a wood. |
|-------------------------------------|---|

List of Species collected in Co. Cork.

In the course of a quarter of an hour a few miles west of Cork, and an hour near to and west of Macroom, 29 species were collected, 9 of which are new records for the county. In the list which follows C. signifies Cork and M. Macroom, and the numbers relate to Praeger's "districts," which I have referred to above.

| | |
|--|-----------------------------|
| <i>Clubiona reclusa</i> Camb. | M., C. New to 4 (mid-Cork). |
| <i>Oxyptila trux</i> Bl. | M. New to Cork. |
| <i>Theridion oratum</i> Clerck (= <i>T. lineatum</i>) | M., C. |
| „ <i>sisyphium</i> Clerck | M. New to Cork. |
| „ <i>varians</i> Hahn. | C. |
| „ <i>instabile</i> Camb. | M. New to Cork. |
| <i>Linyphia triangularis</i> Clerck | M. New to Cork. |
| „ <i>clathrata</i> Sund. | M. |
| <i>Lepthyphantes zimmermannii</i> Bertk. . | M. New to Cork. |
| „ <i>tenuis</i> Bl. | M. |
| „ <i>ericæus</i> Bl. | M. New to Cork. |
| „ <i>alacris</i> Bl. | M. New to Cork. |
| <i>Bathypantes gracilis</i> Bl. | M. New to 3 (West Cork). |
| <i>Orconotides abnormis</i> Bl. | M. New to Cork. |
| <i>Wideria antica</i> Wid. | M. New to Cork. |
| <i>Maso sunderavallii</i> Westr. | M. |
| <i>Pachygnatha degeerii</i> Sund. | M. |
| <i>Meta segmentata</i> Clerck | M. |
| <i>Tetragnatha extensa</i> Linn. | M. |
| <i>Zilla x-notata</i> Clerck | C. New to 4. |
| <i>Epeira diademata</i> Clerck | M. |
| „ <i>cucurbitina</i> Clerck | M. |
| <i>Agelena labyrinthica</i> Clerck | M., C. New to 4. |
| <i>Pisaura mirabilis</i> Clerck | M. |
| <i>Pirata piratica</i> Clerck | M. |
| <i>Trochosa terricola</i> Thor. | M. |
| <i>Lycosa pullata</i> Clerck | M. |
| <i>Nemastoma lugubre</i> Müll. | M. |
| <i>Liobunum blackwallii</i> Meade | M. |

4. Report on the Haliplidæ (Coleoptera): Mr. Omer-Cooper's Investigation of the Abyssinian Fresh Waters (Hugh Scott Expedition).
By the Reverend E. J. PEARCE, M.A. (Cantab.), F.E.S.

[Received September 10, 1930: Read March 3, 1931.]

Nine specimens belonging to this family have been sent me by Mr. Omer-Cooper for determination: these represent two species, one of which is practically ubiquitous around the Mediterranean while the other is interesting, and had previously only been known from the Congo.

1. *HALIPLUS NIGROSIGNATUS* Rég.

The material included two specimens, both of the female sex. This is unfortunate, for to the best of my belief the ædeagus of this species has not yet been described. The locality of the first specimen is as follows:—Abyssinia, Mt. Chillalo, ponds, 7000 to 8000 ft., 8–9. xi. 1926 (*J. Omer-Cooper*). This specimen is very much darker than the other and slightly less heavily punctuated. The locality-label of the other specimen of this species reads: Abyssinia, 7000 ft., Mt. Chilalu, 8. xi. 1926 (*J. Omer-Cooper*).

I am indebted to the late Herr Alois Zimmermann, of Munich, for the determination of these two specimens. Abyssinia is a new area for the occurrence of this species: it had previously only been recorded from the Congo. To quote Herr Zimmermann's letter to me: "Interessant ist *H. nigrosignatus* aus Abessinien, der bisher nur aus dem Kongo bekannt ist." He includes this species in Group X. of the genus *Haliplus*, together with the other African species (*vide* Zimmermann, 'Catalogus Coleopterorum,' pars 71, p. 312; also "Die Halipliden der Welt," Entom. Blätter, xx. 1924, Heft 4, pp. 207–8.)

2. *HALIPLUS LINEATOCOLLIS* Marsh.

The remaining seven specimens all belong to this species. The localities are as follows:—

(a) Two examples from the second pond, British Legation, Addis Abeba, 8. ix. 1926 (*J. Omer-Cooper*). These are rather dissimilar from normal Britannic specimens in the following details:—(i.) The general facies of the insects is much darker in colour, forming a general brownish infuscation. This extends to the legs, which are quite pitchy. The specimens are also slightly larger, and appear to me to be more distinctly parallel-sided than the vast majority of British and Continental specimens. However, it is almost proverbially difficult to appreciate, and still more to describe, the shape of a beetle; (ii.) the fourth and fifth lines of elytral punctures at the base are very strongly incurved, while the punctures themselves—at the extreme base—have run together to form what almost amounts to a shallow depression; (iii.) the bases of the thoracic longitudinal striæ in these two specimens are abnormally deep, and are expanded to form a narrow, shallow depression. The incurving of these striæ is also rather marked. In the former respect they resemble a specimen of the variety *pici* Rég. I have from Gibraltar (*ex coll. G. C. Champion*).

A "hair-splitting" systematist might wish to erect these two examples to the rank of another variety of the type. I do not feel disposed to do this.

The ædeagus is entirely similar to that of our British specimens of *lineatocollis*. The latter is a notoriously variable species, of which one variety and two aberrations have already been described. It is now sometimes placed in a subgenus by itself under the name of *Neohaliplus* Net. It has previously been recorded from Europe, North Africa, Asia Minor, and Abyssinia.

(b) The same remarks apply less strongly to the three specimens of this species from the British Legation, pond no. 1, 8100 ft., 8. ix. 1926 (*J. Omer-Cooper*).

(c) Two specimens from the river-bed, Djem-Djem Forest, circa 8000 ft., 2. x. 1926 (*Dr. H. Scott*). These would be quite typical of British examples, lacking the features I have mentioned under (a).

5. Oligochaeta from Burma, Kenya, and other parts of the World.

By J. STEPHENSON, D.Sc., F.R.S., F.Z.S.

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(Text-figures 1-29.)

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INTRODUCTION.

The present paper embodies the results of recent work, done mostly in the British Museum (Natural History), to the authorities of which my best thanks are due for the facilities they have so kindly afforded me.

The specimens here described have come to me from many sources. The largest individual collections are those of Prof. Gates, of Rangoon, who sent me a number of tubes of small earthworms from various parts of Burma, some of them localities from which Oligochaeta had not previously been collected, and Miss Penelope Jenkin, from Lake Naivasha, in Kenya. The material sent by Miss Jenkin consists entirely of Naididae, and forms part of the collection made by the Percy Sladen Expedition to the Rift Valley Lakes in Kenya (1929), an expedition supported from the funds of the Percy Sladen Memorial Trust, the British Association for the Advancement of Science, and the Research Committee of Birmingham University.

Among the other donors I may here mention Major R. W. G. Hingston, who has contributed specimens from the two climatic extremes of Greenland and British Guiana; Dr. Malcolm Smith, to whom are due specimens of three new species of *Pheretima* from the little-known countries of Siam and Annam; Mr. W. Cook, who has sent specimens from Trinidad; Dr. F. A. Rodway, of Nowra, New South Wales; and Dr. F. G. Holdaway, of Toulouse. To these, and other naturalists, my best thanks are due for the opportunity of examining much interesting material.

Examples of all species here recorded (except *Perionyx setnai*) are now in the collection of the British Museum (Natural History).

GEOGRAPHICAL DISTRIBUTION.

The Naididæ collected by Miss Jenkin have yielded two new species, each characterized by a notable peculiarity of the dorsal needle setæ: but zoogeographically these beautiful and fascinating worms are not of great importance. Like other small freshwater creatures, e.g., rotifers, etc., they are easily transported, and a number of genera, even perhaps of species, are of world-wide distribution. Thus, to mention only species collected in Kenya, *Nais communis* occurs commonly throughout Europe, as well as in India, Persia, and Patagonia; *Pristina longiseta* in Europe, India, North America, Columbia, Peru, and south-western Australia; *Pristina æquiseta* in Europe, India, Columbia, and Tanganyika; *Aulophorus tonkinensis* in India, Tonkin, and Java.

No great surprises are contained among the other groups. *Woodwardiella* is a genus of Megascolecinae the 22 species of which are widely scattered throughout the Oriental and Australasian region; the new species (*W. pumila*) here described from Bhamo, in Burma, occurs 400 miles from the nearest previous record of the genus (Buthidaung, Lower Burma). The new species of *Pheretima*, from Siam and Annam, are what would be expected, since these countries are almost in the heart of the *Pheretima*-region.

One new African species of *Dichogaster* is here described, and a number of the small peregrine forms (*bolauï*, *modiglianii*, *saliens*) are recorded from places in Burma; *D. sinuosus*, also a new species, here recorded from localities in both the north and south of Burma, is at least semi-peregrine, and may in the future be found to be more widely distributed.

The number of species of *Dichogaster* in the present paper furnishes an excuse for a word of comment in regard to the distribution of this, the second largest genus of the Oligochæta. It is found on both sides of the Atlantic, being endemic in America from California to Ecuador and Dutch Guiana (including also the West Indies), and in tropical Africa from Gambia to the Congo on the one side and Abyssinia to Mozambique on the other: while numerous peregrine species, usually small and easily transported forms, occur in India, the Malay Archipelago, and Polynesia, as well as elsewhere.

There is no difficulty with regard to the distribution of these small species, which are often only about an inch in length and proportionately slender; their ancestors have probably been carried eastwards from Africa in successive stages, perhaps accidentally by early man in his wanderings, in his belongings, or later in merchandise of one sort or another. This is not to say that the same species have been found in Africa, or will necessarily be found there in the future; their peregrinations may have begun long ago, and many of the oriental species now known to us may have been evolved since the original stocks left their African home.

But in regard to the relation between the American and African species (the original home of the genus being in America), it seems to be necessary to assume an Americo-African land-bridge from Central America to tropical Africa. As it happens, in the current number of 'Nature,' which is before me as I write, I find a confirmation from another side of what students of the Oligochæta have postulated. In an abstract of a lecture (Ihering, '30), the full text of which is not yet available, it is said:—"Dr. von Ihering considers that the North and the South Atlantic were separated until the Miocene period by land that extended from West Africa to the Antilles and South America. . . . The faunas of the North and the South Atlantic first intermingled [i. e., the bridge was broken] in the Upper Miocene period." According to Prof. J. W. Gregory ('29) also, "the Brazilio-Ethiopian connexion lasted until the end of the Oligocene; but it cannot have lasted much later, as the more specialized

mammals and birds—for example, the humming birds—did not use it as a land bridge A slight temporary land-connexion was established in the Upper Miocene, as shown by the migration of *Hipparion gracile* to Europe and of African antelopes to the United States.”

The single specimen of *Gordiodrilus unicus* from Bhaini, Burma, is difficult to account for : but then the standing and relations of the genus as a whole are also difficult to explain. In a recent work (Stephenson, '30) I could only frame for it the following diagnosis :—“Condition of male apparatus very various—incompletely or irregularly microscolepine, or showing a tendency to balantine reduction, or megascolepine. Two or one or no gizzards. A single œsophageal sac, or a pair, in ix. Holandric, metandric, or proandric. Spermatheca without diverticula on the duct, but sometimes with evaginations at the ectal end of the ampulla.” This is so indefinite as to be meaningless ; and, if I may quote further, “it seems to me that the Ocnodrilinae, which probably arose in Africa, have burst forth luxuriantly in many directions ; and after separating off the well-defined genera, there are left a large number of forms, as a heterogeneous aggregate which cannot as yet be broken up into separate genera.” This heterogeneous aggregate is our present genus *Gordiodrilus*, which occurs scattered throughout the greater part of Africa, and has only with certainty been found elsewhere on one occasion, namely, in South India. What the present species is doing in a remote part of Burma, perhaps 1500 miles from its nearest relative (*G. travancorensis*, the South Indian species just referred to), cannot at present be stated.

Rhinodrilus is already known as one of the characteristic genera of Venezuela ; the present record of the occurrence of a species in the island of Trinidad represents, therefore, only a slight extension of the known territory of the genus. The same may be said of the discovery of a third species of *Pontoscolex*, *P. hingstoni*, in British Guiana ; one of the two previously known species (*P. lilljeborgi* Eisen) inhabits Central America, the other (the common *P. corethrurus*) is found in Columbia, Dutch Guiana, Ecuador, and Brazil, and, in addition, has been transported all round the world in the tropical belt.

ON NOMENCLATURE IN THE ENCHYTRÆIDÆ. ETC.

It is often difficult, or impossible, to be certain as to which, out of the species of Enchytræids now known to us, are those described under various names by the older authors. In the earlier days of Oligochæte investigations, when the methods of discrimination employed were much less refined than at present, there was no apprehension of the variety of internal structure that might be concealed under the simple exterior of an Enchytræid worm. The early descriptions of many of these worms, therefore, are drawn on such broad lines that they cover several of the species now known.

Imagine a description of this kind, which will apply to, say, six species, as species are now reckoned. A second observer comes along, meets with one of these six species, recognizes that it is capable of inclusion in the broad diagnosis left by his predecessor. Thinking to give greater precision, he fills out the description by subjoining a few additional features. Another observer, with the original description in his hand, meeting with another of the six species, does the same, producing another improved description. Yet a third observer, in possession of still another of the numerous species to which the original description is applicable, does the same thing.

Another author now puts together the three descriptions, which may or may not be mutually contradictory in places, but which in any case do not apply to the same worm, and produces a composite diagnosis which, though

labelled with the name given by the original observer, represents nothing in the actual world whatever. Lastly, in order to bring their own specimens into line, some authors will make not only additions, but also corrections, to the original description, and so make the confusion still worse.

As an example, the original description of *Lumbricillus pagenstecheri* (Ratzel, '69) is so little precise, according to present standards, that we cannot even state to which of our present genera it belongs. Among the characters given, however, are the numbers of the setæ (6 to 10 per bundle, but usually 7 or 8) and the shape of the cerebral ganglion (broader than long in the proportion of 12 : 11; slightly excavated behind—though while the figure shows a slight indentation in front, behind there is only the curve due to the arching of the nerve-ring over the pharynx, and no indentation of the margin of the ganglion whatever). In the diagnosis of the species as now current (as given in each of three useful compilations—all, no doubt, often consulted by workers), the number of the setæ is given as usually 5 (occasionally 4 or 6) in the ventral, usually 3 (occasionally 2) in the lateral bundles; while the cerebral ganglion is said to be longer than broad, slightly indented in front, and *deeply* so behind. It seems quite safe to say that if there is any worm to which the current diagnosis applies, it is not *L. pagenstecheri* (Ratz.).

Another worm about which there is liable to be a similar confusion is *Lumbricillus profugus* (Eisen). Here I take as the basis of my comparison Eisen's amended account ('79).

Ferronière ('99) describes two specimens from the west coast of France which he assigns to this species; in the first, amongst other characters, the setæ were 5 in all bundles (8-9 in Eisen's original account), cœlomic corpuscles were few (absent in Eisen), the male funnel 5 times as long as broad ("square" in Eisen), and becoming gradually thinner posteriorly. The second specimen was only 5 mm. long (Eisen's specimens were 18 mm.), and the spermathecæ appear to differ considerably. Southern ('13) says of Ferronière's specimens that they probably belong to another species; with this I agree, at any rate as regards the second of the two specimens; the first might possibly belong to the same species as Eisen's worms.

Southern himself recorded *L. profugus* from Clare Island (Ireland); but in his specimens the male funnel was much longer in proportion to its diameter (3-6 times as long as broad) than the original description has it (where it is called "square"), while the spermathecal duct was about twice as long as the ampulla (the figure of Eisen's original shows it as just about the same length). In the absence of a full description, therefore, it seems doubtful whether Southern's species is the same as Eisen's.

Delphy ('21) states that *L. profugus* is identical with *pagenstecheri* (whatever *pagenstecheri* may be) (n'est guère qu'une variété du *P. pagenstecheri* (Ratzel)); though Beddard ('95) had previously distinguished *profugus* and *pagenstecheri* by the absence in the first and presence in the second of copulatory glands. We may, however, I think, conclude from Eisen's description ("irregular nervous enlargements in some of the segments") that he really saw copulatory glands in *L. profugus*.

It is thus at present obviously impossible, in recording worms suspected to belong to species such as these, to be content with giving a name and locality, with or without the addition of a few notes on characters which differ to a greater or less extent from the (unspecified) description which the writer takes as his norm; such a practice can only add to the confusion that already exists.

I have accordingly not felt able to escape from the necessity of giving a fairly complete account of a worm which *may* be Eisen's *Archienchytræus profugus*, but is pretty certainly not identical with some of the worms described by other authors under that name. This is, I think, what will have to be done in a number of cases; the essential thing is to have reasonably complete accounts, based on modern methods of investigation, of the common Enchytræids. When we are in possession of these it will be possible to discuss how far the older descriptions correspond, and whether or not we are justified in continuing to employ the familiar names.

It is for somewhat the same reason that I give below a full description of *Aulophorus tonkinensis*: this has not so far been done, Vejdovsky's original account ('94) having been based on a fragment only, though here the particulars added by Michaelsen ('05) fairly well supply the need.

ON A SUPPOSED ENDOPARASITIC OLIGOCHÆTE.

Two specimens of *Dichogaster bolawi*, said to have been washed out of the vagina of a native woman during douching, were handed over to me for identification by Dr. H. A. Baylis, of the British Museum (Natural History), who had them from Dr. G. M. Heydon, of the Australian Institute of Tropical Medicine, Townsville, N. Queensland (in future the School of Public Health and Tropical Medicine, Sydney, N.S.W.), who in turn received them from Dr. T. C. Backhouse, of Rabaul, New Guinea. Dr. Backhouse, in a letter to Dr. Baylis, states that he received them from Dr. E. J. Ryan, Kavieng, New Ireland (Neu Mecklenburg).

Endoparasitic Oligochaeta are extremely rare. Michaelsen ('26) has described *Schmardaella lutzi*, found in the ureters of the frog *Hyla venulosa*; and I have recently found a species of *Nais* (*N. bauchiensis*) parasitic in the Harderian glands of the frogs *Phrynomerus bifasciatus* and *P. microps* (Stephenson, '30 a). A number of species of Enchytræids and Lumbricids have been recorded as internal parasites of man (cf. Stiles and Hassall, '26, and Stephenson, '30); but suspicion must attach to all these cases, most of which are doubtless to be explained by the urine, faeces or vomit in which the specimens were said to have been found having been received into dirty vessels already containing the worms, and some, probably, by deliberate deception. In the present case it is possible that the worms may have crawled within the vulva or into the vagina while the woman was squatting on the ground; at any rate, in the absence of details, there is no reason to assume a prolonged sojourn of the worms in the vagina.

MISCELLANEOUS OBSERVATIONS.

A few other points also are of some general interest. True giant setæ, though well known in *Pristina aquiseta*, do not seem to have been observed hitherto in *P. longiseta*. Since the latter is quite a common worm, their occurrence in this species can only be occasional, and it is a question to what factor or factors the development of the giant setæ is to be attributed. The matter has been discussed for *P. aquiseta* by Hempelmann ('23).

As in India, and again in Germany, so in Lake Naivasha, Kenya, a blind variety (without eyespots) of *Nais communis* has arisen, apparently independently in all these localities.

The association of *Fridericia striata* with a dipterous larva, and the manner in which the larva preys on the worms, seems interesting.

Family NAIDIDÆ.

Genus NAIS Müll., em. Vejd.

NAIS COMMUNIS Pig.

- P. 181. L. Naivasha, Kenya, Sta. vi. 26. vi. 29. Miss P. M. Jenkin. Five specimens.
 P. 191. Same locality, Sta. i.; depth 0.5 m., over *Ceratophyllum*. 27. vi. 29. Same collector. Two specimens.

Two specimens of the first batch are partly enclosed within the leaves of a water-plant; in one the head end projects freely, in the other the tail.

Length of a single animal 1.7 mm., of a chain of two 2 mm.; diameter 0.17 mm. $N=15$.

Prostomium short, very blunt and rounded. No eyes.

Ventral setæ of segments ii-v 3, 4, or 5 in a bundle, $73\ \mu$ long, less than $2\ \mu$ thick; the curve of the shaft slight, the nodulus proximal to the middle of the shaft (proximal:distal::2:3 or 3:5); prongs long, slender, not diverging much, about equal in thickness at the base, the outer one-third as long again as the inner. Those of the rest of the body are mostly 4 in a bundle, 3 towards the hinder end, $37-42\ \mu$ in length, $2\ \mu$ in diameter, curves of shaft more pronounced, nodulus distal to middle (proximal:distal::3:2 or 5:3), inner prong distinctly longer, and quite twice as thick as the outer at the base.

Dorsal setæ in bundles of one hair and one needle: the hairs $70\ \mu$ long, a little more than twice as long as the needles, but much less than the diameter of the body; the needles $33\ \mu$ long, the curved, somewhat sickle-shaped distal portion of the shaft taking up one-fifth of the total length, the prongs as described by previous authors.

It will be noted that the present specimens have no eyes. The species was originally described by Piguet ('06) and subsequently by me ('09, *Nais variabilis* var. *punjabensis*), by Michaelsen ('09), and Piguet ('13) as possessing eye-spots; later I found specimens without eyes, which I distinguished as var. *cæca*, from Travancore, Kasauli in the Western Himalayas, Manipur in Assam, and Madras (Stephenson, '10, '18, '24, '25); individuals without eye-spots occur also in Germany (Ude, '29). If a var. *cæca* is admitted, it should be understood that the blind individuals have originated independently in the several localities.

Another peculiarity of these specimens from Lake Naivasha is the shape of the prostomium, which is blunt and stumpy. Piguet describes and figures it as elongated, but in Indian examples it is short and rounded (var. *punjabensis*, cf. Stephenson, '23), and in specimens of var. *cæca* from Manipur, which I have re-examined, it is roughly equilaterally triangular, with a rounded apex.

The details given regarding the setæ will enable comparisons to be made with previous descriptions of the species and its varieties; there are a few differences which, however, need not be specially mentioned.

Genus NAIDIUM O. Schm.

NAIDIUM JENKINÆ, sp. n. (Text-fig. 1.)

- P. 178. L. Naivasha, Kenya, Sta. vi.; shallow, over vegetable debris, noon; pH 7.8. 26. vi. 29. Miss P. M. Jenkin. Two specimens.

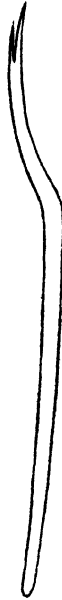
Length of chains of two individuals 2.5-3 mm.; diameter 0.22 mm. Segments of anterior component 19, followed by a budding zone; of posterior component 13 or 19, followed by a posterior region in which separate segments are not yet differentiated; thus $n=19$. In the newly produced head of the posterior

component of the chain at least 6 new ventral bundles of setæ are seen to be forming; I almost thought I saw 7, but this is improbable, since (segment i being always achætous) it would mean that a total of 8 new head-segments was formed (instead of 7, as usual in the genus).

The prostomium is prominent, in the form of an equilateral triangle with a rounded apex. The anus is dorsal. There are no eyes.

The ventral setæ are at first 4, then 5 and 6 per bundle; towards the hinder end the number diminishes to 3 and 2. In length they are 47–55 μ , in thickness 2 μ ; the shaft is moderately curved, the nodule distal to the middle of the shaft (proximal:distal::3:2, or less markedly distal, 16:13); in the anterior segments the nodule is at the middle of the shaft or nearly so. The prongs of the setæ are of equal length, the inner being half as thick again, or even twice as thick, as the outer.

Text-figure 1.



Dorsal needle-seta of *Naidium jenkinsi*, sp. n. $\times 120$.

The dorsal setæ begin in segment ii, and the bundles consist usually of one hair and one needle, occasionally towards the anterior end of two hairs and one needle, or once of two hairs and two needles. The hairs are smooth, and project from the body for a length of 165–234 μ (so that their total length is somewhat greater than this); the longest hairs are thus fully equal in length to the diameter of the body; when they are two in a bundle one may be short and thin. The needles (text-fig. 1) are 62–65 μ long, and 2 μ in thickness; they are slightly sickle- or bayonet-shaped, the distal curved portion being one-third of the length of the whole seta, and ending in two large and unequal prongs the inner and longer prong, which is also distinctly the thicker, is 6 μ in length, the outer 4 μ , and the angle between them is narrow; the length of the prongs relatively to the curved portion of the shaft may be even greater than is shown

in the figure—more than one-third of the length of the sickle-curve; the nodulus is not distinct.

The alimentary canal swells out in segment vii; I cannot, however, distinguish any definite "stomach," or any indication of intracellular canals in the epithelium of this region of the gut; but it is to be remembered that only two specimens were available. Other details of the internal anatomy were not visible.

The remarkable feature of these worms is the relatively very great size of the fork of the dorsal needles. The specimens come nearest to *Naidium roseum* Pig. (Piguet, '06), which, however, has a somewhat elongated prostomium, ventral setæ with the outer prong longer than the inner, hair-setæ distinctly toothed (according to Schuster, '15, but not according to Piguet, '09), dorsal needles with a distinct nodulus and prongs relatively much smaller (according to the figure) than in the present specimens, and the commencement of the intestinal dilatation in segment viii; *n* appears to be somewhat larger in the present specimens (19 as against 16 or 17). *Naidium roseum* has apparently only been obtained in two localities—in the Seyon at Neuchâtel on two occasions (Piguet, '06, '09), and once in Saxony (Schuster, '15).

Genus PRISTINA Ehrbg.

PRISTINA LONGISETA Ehrbg. (Text-fig. 2.)

P. 181. L. Naivasha, Kenya. Sta. vi. 26. vi. 29. Miss P. M. Jenkin. Two specimens.

The characters of these specimens agree for the most part with the current descriptions, but the relations of the anterior ventral setæ require a few words.

Text-figure 2.



Giant seta (ventral seta of segment iii) of *Pristina longiseta* Ehrbg. $\times 93$.

Ordinarily those of segments ii and iii are somewhat longer than those of the following segments, and those of iii at least are somewhat thicker also. In the present specimens, however, the ventral setæ of iii are of particularly

striking appearance (text-fig. 2), and are true giant setæ, like those known in *P. æquiseta* (v. inf.) ; in length they are $70\ \mu$, in thickness $3.5\ \mu$, the curves of the shaft well marked, the nodulus distal, though only slightly so (proximal : distal : : 9 : 8) ; of the two prongs the outer is large and well hooked and the proximal very small, as in the similar setæ of *P. æquiseta* ; there are only two setæ in each bundle.

The ventral setæ of segment ii are $66\ \mu$ in length, but they are quite slender, their thickness being only about $1.7\ \mu$; the curves of the shaft are slight, as in the anterior ventral setæ of many species of *Nais* ; the prongs are relatively long, the outer a third longer than, but only half as thick as, the inner ; the nodulus is proximal (proximal : distal : : 8 : 11).

The corresponding setæ of segment iv are $51\ \mu$ in length, and about $1.5\ \mu$ in thickness : the outer prong of the fork is a trifle the longer of the two, but the inner is rather thicker at the base, and both prongs are shorter than those of the setæ of segment ii : the nodulus is distal (proximal : distal : : 3 : 2).

PRISTINA ÆQUISETA Bourne.

P. 176. L. Naivasha, Kenya, Sta. vi. : just over weeds and debris near shore. 26. vi. 29. Miss P. M. Jenkin. Two specimens.

P. 181. Same locality, Sta. vi. Same date and collector. Two specimens.

P. 191. Same locality. Sta. i : depth 0.5 m. over *Ceratophyllum*. 27. vi. 29. Same collector. A single specimen.

The giant setæ, similar to those just described for *P. longiseta*, are well known in this species, where they occur, alone or with others of smaller size, in the ventral bundles of segment iv or v or both of these : they do not occur in all individuals. In the present specimens, while in most the ventral setæ of segment iv are fully developed giant setæ, in one they are merely somewhat thicker than those of neighbouring segments.

In this example, to compare the ventral setæ of the anterior segments, those of ii are $53\ \mu$ long and $1.4\ \mu$ thick, the distal prong being considerably the longer but rather thinner at the base than the proximal, and the nodulus proximal to the middle. In iii the length is $45\ \mu$, the thickness about the same as in ii, the distal prong slightly the longer, while both prongs are about equal in thickness at the base, and the nodulus is rather distal. In iv the setæ are $53\ \mu$ long and $2\ \mu$ in thickness (a difference which is immediately perceptible on examining with the high power), the distal prong half as long again as the proximal and not quite so thick as the latter at the base, and the nodulus slightly distal. In v the length is $46\ \mu$, the thickness $1.5\ \mu$. In posterior segments the ventral setæ are about $43\ \mu$ long and $1.7\ \mu$ thick, the prongs of equal length, the proximal twice as thick as the distal at the base, and the nodulus at the middle of the shaft.

None of the specimens showed any signs of sexuality.

Genus DERO Ok.

DERO sp.

P. 178. L. Naivasha, Kenya, Sta. vi. : shallow, over vegetable debris ; noon ; pH 7.8. 26. vi. 29. Miss P. M. Jenkin. A single specimen.

Since only a single specimen was available, and the gills were much contracted and impossible to distinguish accurately or to count, I will not attempt a specific determination of this worm.

Genus AULOPHORUS Schmarda.

AULOPHORUS TONKINENSIS (Vejd.). (Text-fig. 3.)

- P. 178. L. Naivasha. Kenya, Sta. vi., shallow, over vegetable debris, noon; pH 7.8.
 26. vi. 29. Miss P. M. Jenkin. A number of specimens.
 P. 181. Same locality, Sta. vi. Same date and collector. Several specimens.
 P. 191. Same locality, Sta. i.; depth 0.5 m., over *Ceratophyllum* 27. vi. 29. Miss P. M. Jenkin. A number of specimens.

A certain number of the specimens, but not the majority, were contained in tubes from which one end or the other of the worm projected. The tubes are not all of the same character; some are hyaline and semitransparent; others darker and rather opaque, in consequence of the foreign particles and debris of various sizes which have been incorporated or which adhere to the surface; the tubes are straight, open at both ends, 4 mm. long and up to 0.4 mm. in diameter. I may mention here that Dr. P. Bovien, at that time resident in Djombang, Java, informed me in a letter that *A. tonkinensis* "will form nice cases of glass-powder if forced to do so," and that it "is able to hang (and 'crawl') under the water-surface, much like a *Limnæa*."

The length of the single animal is 2 mm.; chains of two measure from 2 to 3.4 mm. In diameter the worms are 0.2 to 0.25 mm. The number of segments of the single animal is 23-27, with a zone of new formation at the hinder end in which segments are not yet differentiated. $N=14$ (once), 15 (often), 16 (twice), or 17 (once); a number of new setal bundles are formed at the hinder end of the anterior animal of the chain before separation.

The head is, as a rule, rather bulbous, with the rather small and pointed snout-like prostomium stuck on in front, with a retroussé effect—slightly turned up. What may be called the neck region is somewhat constricted. There are no eyes.

The setæ, both dorsal and ventral, are of relatively large size. The ventral setæ of the anterior bundles (segments ii-v) may be as many as 7 per bundle; in length they are 110-117 μ , in thickness 2 μ : the proximal curve of the shaft is very slight, and the outer prong is about a third longer than the inner, which is the stouter of the two: the nodulus is proximal to the middle of the shaft (proximal:distal::4:7, or 11:18, or even 1:2 (the latter in segment ii)). In the segments behind v there are 5 and 4, or even only 3 setæ per bundle, 57-61 μ long and 2 μ in thickness: the proximal curve of the shaft is well marked, the proximal prong rather the longer, and twice or more than twice as thick as the distal, both prongs being much shorter than those of the more anterior setæ; the nodulus is distal (proximal:distal::4:3 or 20:13, or 21:12), the position probably varying with the position of the seta in the bundle (*cf.* Stephenson, '15).

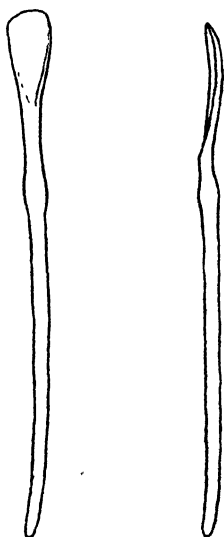
The dorsal setal bundles, which begin in segment vi, are usually composed of one hair-seta and one needle; two hairs and one needle were seen only twice. The needles vary in length from 66 to 77 μ , many being about 74 μ : the distal end is expanded and webbed, and, seen edgewise, may appear slightly hollowed or spoon-shaped; the span of the web is 6-7 μ , and one prong, or the border of the web, may be much thicker than the other (text-fig. 3), which may not be strengthened at all; the shaft is almost perfectly straight, and there is a slight nodulus just proximal to the expanded distal end. The hair-setæ are about 0.125 mm. in length—less than the diameter of the body.

The palps at the hinder end vary in length; at the time of separation of the posterior animal the newly-produced palps are about 0.11 mm. long, and at this stage no gills have developed (or at least none are visible); later the palps may measure 0.2-0.24 mm. They extend backwards parallel to each

other, and their ends are rounded—in some cases slightly swollen or bulbous, in others not.

The gills, which are normally two pairs, are finger-shaped, the dorsal longer than the ventral pair; but I would not call them "lead-pencil-shaped," *i. e.*, they are not tapered to a fine point. They seem to vary in number, though allowance must be made for the possibility of mistakes owing to the contraction of the gills and the curling over of the edge of the branchial fossa in preserved specimens. Thus two pairs may be visible, as just described; or two pairs, of which one pair is of moderate length, the other abnormally small. Or there may be

Text-figure 3.



Dorsal needle-setae, seen on the flat and from the side, of *Aulophorus tonkinensis* (Vejd.). $\times 92$.

one pair only—and this more than once, and not in specimens which had recently separated at the budding zone; for example, in an animal of 27 segments, with large palps; or in the hinder animal of a chain which was almost ready to break up. Once only a single gill was seen. For another example of variability in the number of gills, cf. *Aulophorus furcatus* (Stephenson, '16).

The narrow oesophagus swells out to form the intestine in segment viii, but there is here no special stomachal dilatation; on the contrary, the intestine in segment viii is not quite as wide as in ix and subsequent segments. The dorsal vessel is situated ventro-laterally on the left side (? on the right side in one specimen). One specimen showed commencing sexual organs.

AULOPHORUS FLABELLIGER, sp. n. (Text-fig. 4.)

P. 178. L. Naivasha, Kenya, Sta. vi.; shallow, over vegetable debris; noon; pH 7.8. 26. vi. 29. Miss P. M. Jenkin. Several specimens. Possibly there may have been some specimens of this species along with *A. tonkinensis* in other tubes.

Some of the specimens were in tubes, thin and delicate transparent or hyaline structures, regularly cylindrical in shape, slightly curved, 4.5 mm. in length and 0.3 mm. in diameter, with only a very fine granular debris

adhering, but incorporating a quantity of fine filaments (? a filamentous alga) ; the greater part of the body, usually the tail, projects from the tubes.

Length of the worms about 2.75 mm. ; diameter 0.2 mm. Segments 27, 28 · $n=17$.

The head is not, as in *A. tonkinensis*, bulbous and thicker than the succeeding region. The prostomium is very blunt and round, not small and retrousse. There are no eyes.

The ventral setæ of segments ii-iv are 5, 6, or 7 per bundle, 106-127 μ in length, and 3 μ in thickness ; the prongs are relatively long and do not diverge much, the outer one being half as long again as the inner, which is slightly thicker at the base ; the shaft is relatively straight, and the nodulus proximal to the middle (proximal : distal :: 5 : 8, or 2 : 3). The ventral setæ of more posterior segments are 4 per bundle—very regularly so (occasionally 5) till close to the hinder end ; in length they are 49-53 μ , and in thickness about 2 μ ; the inner of the two prongs is twice as long as the outer and much stouter—about 3 times as stout at the base ; the shaft is more curved proximally than in the more anterior bundles, and the nodulus is distal, the ratio varying, probably with the place of the seta in the bundle (proximal : distal :: 8 : 5, or 2 : 1, or perhaps even more).

The dorsal bundles begin in vi, and consist regularly of one hair-seta and

Text-figure 4.



Dorsal needle-setæ, seen on the flat and from the side, of *Aulophorus flabelliger*, sp. n. $\times 120$.

one needle. The needles constitute the distinguishing feature of the species ; they measure 50-60 μ in length ; the shaft shows only a very slight curve, and is rather less than 3 μ in thickness ; the distal end is very greatly expanded in the form of a fan, and has an irregularly triangular shape, one lateral border being much shorter than the other, which continues the direction of the shaft (text-fig. 4). The span of the web, measured near its oblique terminal edge, is 18-19 μ ; the shorter lateral border is always much thickened, and does not lie in the same plane as the longer, which is not much strengthened. The free margin of the web is finely indented or impressed in the half of its extent which is adjacent to the shorter and thicker border, so as to give here a comb-like appearance, with about 9 indentations ; but in the other half of its extent the free margin is so thin as sometimes to be not delimitable. The hair-setæ are 110-115 μ in length—not more than about twice as long as the needles, and much shorter than the diameter of the body.

The palps are long (0.32 mm.), cylindrical with a conical base, with rounded tip, and parallel backwards. The gills, 3 pairs, visible inside the contracted branchial fossa, are also finger-shaped, the ventral pair being apparently the longest and the dorsal the shortest.

The alimentary canal shows a slight stomachal dilatation in segment ix in one specimen ; in another the canal begins to dilate in segment viii. Chloragogen cells begin in vi. One specimen shows a clitellum.

Remarks.

The distinctive character of the present form is the shape of the dorsal needles. The species belongs to the group in which the dorsal bundles begin in segment vi and which possesses palmate or webbed dorsal needles; it apparently comes nearest to *A. tonkinensis* and *A. schmardai*. A comparison with *A. tonkinensis* may be made by the help of the foregoing description of this species; in *A. schmardai* $n=15$, the prongs of the dorsal needles diverge at an acute angle and the web between them has a smooth margin, the gills do not project from the fossa in any (preserved) specimen (many specimens were available for examination) and are only recognizable in sections.

Family ENCHYTRÆIDÆ.

(Genus ENCHYTRÆUS Henle, em. Mich.

ENCHYTRÆUS ALBIDUS Henle.

Kugssuk, near Godthaab, W. Greenland; sea-level, in soil underneath stones and patches of sea-weed on sea-shore near high-water mark. 30. vi. 28. Major R. W. G. Hingston. Numerous specimens.

Genus LUMBRICILLUS Örst.

LUMBRICILLUS PROFUGUS (Eisen).

Kugssuk, near Godthaab, W. Greenland. Major R. W. G. Hingston. A number of specimens.

Length ca. 13–14 mm.; diameter 1 mm.; Segments 58–63; colour (preserved) yellow.

Prostomium rather small, bluntly pointed.

I at first thought the setæ were "enchytræine," i.e., straight at the distal end; there is, however, often a slight distal curve—perhaps, indeed, oftener than not. In front of the clitellum the numbers per bundle are 5–7 ventrally, and the same (occasionally 4) laterally; behind the clitellum 3–4 both ventrally and laterally (occasionally 5 laterally).

The clitellum is much more easily distinguishable than in the former species (*Enchytræus albidus*), and is much thicker in sections; it covers segments xii–xiii with portions of neighbouring segments, extending forwards as far as the setæ of xi.

The male apertures are on segment xii, on small papillæ.

A conspicuous feature of the sections is constituted by numerous very deeply staining mucous gland-cells in the superficial epithelium; these are arranged in parallel transverse rows, successive rows being fairly close together.

The cœlomic corpuscles are spindle-shaped or oval, mostly about $42\ \mu$ but sometimes as much as $50\ \mu$ in length, and up to $20\ \mu$ in transverse diameter; they are granular and darkly staining, with a small round nucleus. They may be numerous, but in some specimens are scantier than in others; in one few are to be seen. They are produced on the septa, sometimes from obvious foci.

There are no salivary glands. A pair of post-pharyngeal bulbs are present, of the usual constitution, near the middle line behind the pharynx; each is hollow at the base, and the lumina of the two structures run together and join in a small dorsal diverticulum of the posterior part of the pharynx. Septal glands are present in segments iv, v, and vi.

The œsophagus swells out, but neither markedly nor very suddenly, in segment xii to become the intestine, and the character of the epithelium alters here, becoming lower. Both ciliate and gregarine parasites occur in the gut in the anterior part of the body, and in one specimen a gregarine cyst was seen in the body-cavity.

The peritoneal covering of the intestine consists of remarkably high clear cells, 40–90 μ high, perhaps even 100 μ in places. Each cell contains—indeed, is almost entirely composed of—a series of clear vacuoles arranged in a single row, with very little stainable cytoplasm between and around them.

The dorsal vessel begins in the anterior part of segment xv; the blood stains deeply with eosin, which indicates that it contains hæmoglobin, and therefore was reddish in life.

The preseptal portion of the nephridia consists of the funnel only, and is very small: the postseptal is elongated. The duct appears to be of varying form, perhaps according to the part of the body or the attitude of the worm: it originates at the hinder end of the postseptal portion, and is of some thickness. In one (whole) specimen it appeared to be ovoid, narrower at its beginning than lower down in its course; in one it appeared to bend first forwards and then outwards to the surface: in another to be continued directly backwards from the postseptal and not to be marked off in any way from the postseptal—indeed, in general there was in the sections, as well as in a specimen isolated by teasing, no demarcation of the duct from the hinder end of the body of the nephridium. In length the duct appeared to be as long as, or sometimes slightly longer than, the postseptal portion.

The cerebral ganglion could not be accurately seen in any of the specimens mounted whole. According to frontal sections it is square in shape and very slightly excavated (almost straight) both in front and behind.

The testes are many-lobed: numerous sacs are cut in section in segments x and xi, and once as far forward as vii: all seem to originate from a single stem attached by a very narrow base.

The body-wall in these specimens is too opaque to allow much of the internal anatomy to be discerned in the animal mounted whole, so that it is very difficult to give an estimate of the proportions of the funnels from such an examination: sections, of course, are liable to give a false impression, since the whole length of the funnel is not usually cut at once. The first impression, in many sections, is that the funnel is not much longer than broad; but a more prolonged examination shows that they are twice, or in other cases three times, or possibly even four times as long as wide.

The vas deferens forms a few rather close coils just behind the funnel, in segment xii, to which it is confined; in diameter it is 12 μ . The penial body is of moderate size, 250 μ in longitudinal diameter, ovoid or almost spherical in shape, with a well-marked muscular layer underneath the peritoneum. The male papilla is quite small.

Large yolky ova are present in segments x, xi, and xii; the ova do not seem to get back behind the ovarian segment. There is no trace of an ovarian funnel or duct.

The spermathecal ampulla is spherical, but with a slight protrusion where it fuses with the œsophageal wall, so that its shape is that of a short round pear; in diameter it is 0.2 mm. It is lined with a low epithelium; its muscular coat consists of a few fibres which do not cover the whole circumference (as seen in sections). The ampulla joins the wall of the œsophagus; in some cases there is, in others there is not, a patent communication between the ampulla and œsophageal lumen; in some a disintegration of the wall of the ampulla and of

the œsophageal epithelium is beginning or has advanced some way ; but the communication does not seem ever to attain the magnitude of that in *Enchytraeus albidus*, and always remains small.

The spermathecal duct is about equal in length to the ampulla ; its diameter (inclusive of the cells around it) is 0.23 mm.—slightly greater than that of the ampulla. There is no epithelium directly lining the lumen ; the only cellular layer of the duct-wall is that of the gland-cells, which have their nucleated and rounded ends internal, and abut on the lumen with their thin fibre-like ectal ends : these thread-like ectal portions of the cells penetrate between the fibres of the conspicuous muscular coat of the duct. The cells lie somewhat obliquely, their ental ends higher than the thin ectal ends, and the longest are $140\ \mu$: their obliquity explains why the total diameter of the duct is only 0.23 mm. The muscular layer of the duct is longitudinal (the fibres lying along the duct) : in a transverse section of the duct the fibres are arranged round, though at some little distance from, the lumen with a beautiful regularity.

In the lumen of the duct either the thin ends of the cells, or more probably some secretion, stains very deeply, so as to give an internal layer in or immediately bordering the lumen. This material seems to be separate from the ends of the cells and to lie freely : in sections it appears as a ring, leaving an empty space in the centre of the duct.

Copulatory glands are present in segments xiv and xv ; they are of large size, that in xv being the larger of the two ; usually the glands spread widely on each side, far beyond the nerve-cord, over a span nearly equal to the diameter of the body-cavity ; in one case, however, the glands were of considerably smaller transverse extent. The glands leave the dorsal surface of the nerve-cord entirely uncovered, though they are intimately fused with the ventral side.

Genus FRIDERICIA Mich.

FRIDERICIA STRIATA (Levinson).

Near Uxbridge, Middlesex ; on bark of tree (*Oligochætes* from oxalic and tartaric acid experiments by Dr. Burton). G. H. Mansbridge. Ten specimens, mostly with marks of sexual maturity.

Further information from the donor of the worms states that they were in association with a dipterous larva belonging to the genus *Platyura* of the family Mycetophilidæ ; the larva weaves a kind of web, and on this web secretes small droplets of oxalic acid. The acid has a strong effect on *Enchytraids* ; these die immediately on coming into contact with it, and are eaten by the dipterous larvæ.

The distinguishing character of this species is the presence of two separate, well-defined, and encapsuled masses of gland-cells in association with the ectal end of each spermathecal duct. Ude ('29) states that the inner setæ of a bundle are always shorter than the outer, and ('92) that when there are only 4 setæ per bundle the two inner are about one-third shorter than the outer. I found that the usual number of setæ in a bundle, both ventral and lateral, was 6, but that towards the hinder end the small inner couple of setæ disappeared from the bundles, and the four remaining setæ were all large and of about the same size.

FRIDERICIA UNIGLANDULA, sp. n. (Text-fig. 5.)

On roots of black currant (pretty certainly from somewhere in Britain). 1928. Several specimens.

Length 9 mm. ; maximum diameter 0.5 mm. Most specimens are incomplete posteriorly ; the only one which has an uninjured hinder end has 60 segments.

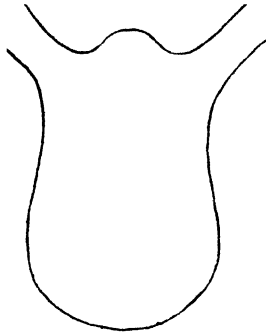
Prostomium small, as if stuck on the anterior end. Head-pore present, in the prostomium ; dorsal pores begin in segment vii.

Ventral setæ 5-8 per bundle in the anterior part of the body, with the ordinary *Fridericia* arrangement of graded setæ ; in the hinder half of the body 5-6 in bundle, the difference in size of the setæ of a bundle being much less marked ; towards the hinder end 4 per bundle, all large, and of approximately the same size. All setæ are of the *Enchytræus*-type.

The body-wall is thick and opaque, and the whole of the internal anatomy has to be studied in sections, longitudinal and transverse.

The cerebral ganglion (text-fig. 5) is somewhat longer than broad ; its hinder end is well rounded, while anteriorly there is a small median, rounded, forwardly projecting prominence, which in sections is seen to be constituted by a mass of nerve-cells. The sides of the ganglion diverge somewhat backwards. There are no copulatory glands associated with the ventral nerve-cord.

Text-figure 5.



Cerebral ganglion of *Fridericia uniglandula*, sp. n.

The coelomic corpuscles are numerous in both pre- and post-clitellar segments ; they are spindle-shaped, oval, or circular nucleated disks, or they may be of somewhat irregular shape. The diameter of a fair-sized corpuscle of circular shape is about $25\ \mu$; but the size varies, and many are smaller than this.

The salivary glands are given off ventro-laterally from the hinder end of the pharynx ; they are narrow tubes, irregularly bent, in segments iv and v ; they present a number of short, irregular branches, some of which are hardly more than nodular excrescences. The "chyle cells" (cells with intracellular canals) constitute the alimentary epithelium of segments xv, xvi, and xvii.

The dorsal vessel begins some distance behind the clitellum, in one specimen definitely in xxii, in another at least as far back as segment xxiii.

The anteseptal portion of the nephridium is relatively large, and contains some windings of the lumen. The duct is short, and, according to the careful examination of a number of sections, its origin varies ; usually it is given off from the lower and inner border of the organ, but once at least it was seen to originate at the outer border, passing underneath the body of the nephridium on its way to the pore ; again it may originate about a third of the length of the postseptal portion from the hinder end (this in the preclitellar segments), or, apparently generally in the postclitellar and sometimes in the preclitellar segments also, near or at the hinder end of the nephridium.

A large number of male cells, some massed together in small aggregates, as well as ripe spermatozoa, are free in segment xi. The male funnels are of large size, and the two side by side take up the whole diameter of the segment; their length is about double their width; the vas deferens, 12μ in diameter, forms a closely-packed coil in the anterior part of segment xii. The penial body is large and flatly ovoidal, measuring 250μ antero-posteriorly and 120μ in height (from the inner surface of the body-wall); it is encapsuled and well defined.

The ova attain a large size, and may take up the whole diameter of a segment; in this condition they may occupy segments xii and xiii; clusters of smaller ova may wander much further, and may be seen sometimes as far back as segment xviii.

The spermathecae occupy the usual position (in segment v). The ampulla is small, 75μ or less in diameter, pear-shaped, the narrower end (40μ) being drawn out towards the œsophagus, with which it communicates by a patent passage. There are a number of diverticula, two to five (five only once); in one specimen two on each side, in a second four on each side, arranged in two pairs; in a third four (two larger and two smaller) on one side and three on the other; in the fourth three (one of these being smaller than the other two) on one side and five (of which two were quite small, mere knobs in fact) on the other; in the fifth (only one side of which was preserved) a cluster of four. The diverticula are given off from the lower part of the ampulla, not from the duct; they are rounded, 36μ in diameter, sessile or only shortly stalked, the stalks, when present, being almost of the same diameter as the body of the diverticulum. The duct is narrow (23μ), bent once or twice or curled in a semicircle or in more than a semicircle; at its inner end it is invaginated upwards into the base of the ampulla.

Associated with the ectal end of the duct there is usually a large gland, 185μ in antero-posterior length, on the left side only in three of the sectioned specimens, apparently on the right side only in another, and absent entirely in the fifth. The cells of the gland are greatly elongated cells of the superficial epithelium, which still reach the surface by narrow necks, so that the gland is continuous with the epithelial layer; the cells have a spongy constitution, and under the microscope appear very similar to those of the male funnels or those of the penial body. The gland is encapsuled by muscular fibres; in three of the four cases it is situated in segment iv and joins the surface just in front of furrow 4/5, the spermathecal duct passing behind it and discharging behind the junction of the gland with the surface epithelium; in the fourth case, however, the gland is in segment v, and takes up the whole length of this segment; it joins the surface between the level of the setæ of segment v and furrow 4/5, and the spermathecal duct passes in front of it.

Remarks.

The gland just mentioned seems to be a peculiar feature of the species; it occurs only on one side, and not always in the same segment. In its characters it differs from the glands of *F. striata*, the species which I examined immediately before taking up the present specimens; the glands of *F. striata* are two on each side, pear-shaped, small, and closely associated with the end of the spermathecal duct; the gland of *F. uniglandula* is single, asymmetrical, its longest measurement antero-posterior, very much larger than those of the preceding species, variable in position, and its neck, where it joins the epidermis, not in immediate contact with the end of the spermathecal duct.

Family MEGASCOLECIDÆ.

Subfamily MEGASCOLECINÆ.

Genus PONTODRILUS E. Perr.

PONTODRILUS BERMUDENSIS Bedd.

Great Barrier Reef Expedition; General Survey, I.M. 2. 5.iv. 23. Two specimens, immature.

The same; I.M. 5. 6.iv. 29. Seven specimens, sexual.

Michaelsen in his revision of the genus ('10), reduces the number of littoral species of *Pontodrilus* to three—*bermudensis*, *litoralis*, and *matsushimensis*—which are distinguished by the characters of the prostatic duct. In the present specimens the duct is large, sharply set off, spindle-shaped and muscular.

Genus WOODWARDIELLA Steph. (=WOODWARDIA Mich.).

WOODWARDIELLA PUMILA, sp. n. (Text-figs. 6 & 7.)

Bhamo, Burmr. 1929. Prof. G. E. Gates. A single specimen, sexually mature.

External Characters.

Length 36 mm.; diameter 1 mm. Flesh-coloured. Segments 114.

Prostomium slightly epilobous, triangular, hinder end rather pointed.

Dorsal pores begin in furrow 6/7.

In the middle of the body setæ *d* are not far from the mid-dorsal line, the interval *dd* being less than *aa*, and also much less than *cd*—about half *cd*; $ab = \frac{3}{4}$ $aa = \frac{1}{2}$ $bc = \frac{1}{2}$ cd ; since *cd* is much greater than *dd*, and somewhat greater than *bc*, the dorsal setæ are not paired. The arrangement is approximately the same at the hinder end. In the region behind the clitellum the setæ are rather further apart, but *dd* is still less than *aa*. In front of the clitellum the interval *dd* is considerably larger than further back, and is about equal to 2 *cd*, or one-third of the circumference; here $ab = \frac{1}{2}$ $aa = \frac{1}{2}$ $bc = \frac{1}{2}$ cd .

The clitellum includes the setal zone of xiv (*i. e.*, two-thirds of xiv) and the whole of xvii (=3 $\frac{2}{3}$); it is ring-shaped and smooth.

The male pores are paired, on xviii, on moderately prominent circular papillæ which lie almost in line with, and are about equal in diameter to, the interval *ab*; they are, however, slightly more internal than *ab*—*i. e.*, the centre of the papilla is nearer to the line of setæ *a* than to that of *b*.

The female pore, or pores—I was not able to distinguish whether there is one or a pair—are apparently on a small whitish papilla situated in the mid-ventral region in the setal zone of segment xiv.

The spermathecal apertures were not seen; the posterior pair may perhaps be in the region of setæ *a* of segment ix.

There are no other genital markings.

Internal Anatomy.

Septum 5/6 is thin, 6/7 and 7/8 are slightly and 8/9 and 9/10 moderately thickened, while 10/11, 11/12, and 12/13 are also slightly strengthened.

The gizzard, in segment v, truncated in front and narrowing somewhat backwards, is small, soft, and somewhat regressive. There are no calciferous glands. The intestine begins behind the prostates.

The last hearts are in segment xiii.

The excretory system is meganephric; in and behind the clitellar region the organs are of rather large relative size and conspicuous, consisting of a number of rather flattened lobes which have not a great extent dorso-ventrally—are

Text-figure 6.

Spermatheca of *Woodwardiella pumila*, sp. n.

not long loops which extend upwards on the body-wall towards the dorsal side of the worm. In segments v and vi the nephridia are tufted and large.

The male funnels are large, conspicuous, and iridescent, free in segments x and xi. I did not identify testes in xi, though I believe I saw them in x;

Text-figure 7.

Distal end of penial setæ of *Woodwardiella pumila*, sp. n. $\times 700$.

but in such a very small worm they might easily escape observation in dissection. The seminal vesicles occupy segments xi and xii; those in xi are of moderate size and not much indented; those in xii are rather large, each with two small, round lobes attached dorsally near the middle line,

The prostates are of the *Pheretima*-type; each consists of a number of smooth, rounded, and deeply divided lobes, the whole gland being contained in segment xviii and causing a bulging backwards of septum 18/19, or occupying both xviii and xix, in which case septum 18/19 lies in a deep cleft between two lobes of the gland. The duct is short, straight, narrow, and shining, and passes transversely inwards.

The ovaries are elongated and stick vertically upwards in segment xiii; they and their funnels are conspicuous structures. There are relatively large ovisacs in xiv.

The spermathecae (text-fig. 6) are two pairs, in segments viii and ix. The ampulla is ovoid and sac-like, the duct cylindrical, as long as the ampulla, and one-third or a quarter as wide. The diverticulum, usually (in three of the four organs) single, is club-shaped, attached to the duct at the middle of its length, in length about equal to the duct, and hence extending upwards alongside the lower end of the ampulla; in one (the right posterior) organ a small secondary diverticulum is present, as shown in the figure.

The penial setae (text-fig. 7) are 0.34 mm. long and 6–7 μ thick at the middle of the shaft: the shaft is almost straight, with a slight distal curve; it tapers gently towards the tip, which suddenly becomes very fine and hair-like in the last 8 μ , and is sometimes irregularly bent. The bending of the terminal region is perhaps due only to its thinness, since in a very young seta still enveloped in its sheath it was straight. The distal portion (80 μ) of the seta is ornamented by a double series of fine incisions on the shaft, hardly to be called teeth or spines, but notches or rather indefinite irregularities.

Genus MEGASCOLEX Templeton.

MEGASCOLEX RODWAYI, sp. n. (Text-fig. 8.)

Hampton, New South Wales; road to the Jenolan Caves; moist ground. Sept. '29. Dr. F. A. Rodway. Two specimens, one in two pieces; both sexual.

External Characters.

Length 120–150 mm.; maximum diameter 4–5 mm. Colour a pinkish or purplish grey, with a pigmented mid-dorsal line in the hinder two-thirds of the body; ventrally light grey, almost unpigmented. Segments of the larger worm 121, of the smaller 99, but here the hinder end appears to be regenerating.

Prostomium epilobous $\frac{1}{2}$ in the smaller, almost tanylobous in the larger; not cut off behind; the sides converging backwards.

Dorsal pores from furrow 4/5; one of the specimens has a rudimentary pore in furrow 3/4.

The setae, small and rather inconspicuous in the anterior segments, are in rings; the dorsal and ventral breaks are considerable, the ventral larger than the dorsal; $aa=3ab$ at the anterior and posterior ends of the body, $=3\frac{1}{2}$ or nearly $4ab$ for some distance behind the males pores, and $=3\frac{1}{2}ab$ for a long stretch in the middle of the body; zz —about $2yz$ in front of the clitellum, $=1\frac{1}{2}yz$ or even less in places for some distance behind the clitellum, and in the middle and hinder regions $=2yz$, or in the smaller specimen often $1\frac{1}{2}yz$. The setae a and b are regularly paired, and separated from c by an interval greater than ab . There are also in many places distinct indications of pairing among the other setae, but too irregularly to be capable of description. The following numbers were counted:—20/v, 20/ix, 22 (10+12)/xii, 20/xix, and regularly 24 in the middle of the body and at the hinder end.

The clitellum, grey in colour, extends over $\frac{1}{2}$ xiii-xvii ($=4\frac{1}{2}$); the furrows are obliterated, but some setæ are visible; dorsal pores are absent, except in the situation of furrow 13/14.

The male pores are on xviii, on rounded, not very prominent papillæ of rather indefinite extent, in line with setæ *ab*. The female pores are perhaps in the lateral parts of a slightly darker transverse area which extends, in front of the setal zone, between the lines of setæ *a*. The spermathecal apertures are two pairs, rather prominent, with distinct lips, lying just outside the lines of setæ *b*, the lips reaching the line of *b*.

A number of preclitellar segments—from segment vi to the clitellum—are more or less swollen and glandular ventrally, more especially x and xi; the swellings include the setæ *ab* on each side, and on the two segments just mentioned are marked by small, round, darker spots, closer together and nearer the middle line in xi, nearer the lateral margins of the swollen areas in x. Similar glandular patches are present on xvi and xvii, with similar darker spots; on xvii the patch is paired, with the dark central spot on each side just internal to and in front of seta *a*; on xvi the swollen areas are continuous from side to side, and the darker spot on each side is not far from the middle line. Finally there are patches also on segments xix, xx, and xxi, feebly marked but with similar spots; in xix and xx the patches are paired, those on xix being further apart than those on xx, the interval between those on xix corresponding to the interval between the male papillæ, behind which they lie; those on xxi are conjoined in the middle line. The patches on xvi, xix, xx, xxi are more definitely papillæ than those further forward—rounded in outline and paired, though, as described above, on certain segments they are confluent in the mid-ventral line.

Internal Anatomy.

Septum 4/5 is thin, 5/6 is scarcely thickened, 6/7, 7/8, and 8/9 are all slightly strengthened, and 9/10-15/16 somewhat or moderately thickened, the middle ones of this series most, though none are very thick.

The gizzard, in segment v, is bulky but very soft; the œsophagus in front of the gizzard was (when the worm was opened) invaginated backwards into it. The œsophagus is segmentally swollen in x-xiii, but there are no calciferous glands. The intestine begins in xvi.

The last hearts are in xii.

The excretory system is micronephridial; in the pharyngeal region (segments, iii, iv, and v), however, the nephridia are tufted. Behind the pharynx and in front of the clitellum the nephridial tubules are arranged in transverse segmental rows; they are denser in the clitellar segments, but behind the clitellum are not well seen, owing partly to poor preservation, though the tubules themselves are also probably more delicate; apparently here they are again in transverse segmental rows, an arrangement which persists into the hinder region. No tubules are noticeably larger than others.

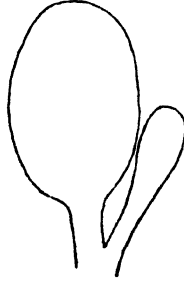
Testes and funnels are free in segments x and xi. Vesiculæ seminales are present in ix and xii, of moderate size, scarcely lobed; those in xii are perhaps a little larger than those in ix, and more granular in appearance, the surface being cut up into very numerous minute lobules, especially the inner surface, which lies on the alimentary canal.

The prostates, rather small and rather deeply lobed, occupy segments xviii and xix. The duct is short and straight, white, shining slightly, rather wider in its ectal portion, and passing transversely inwards.

The ovaries are in segment xiii; funnels were not recognized. Ovisacs are present in xiv.

The spermathecae (text-fig. 8) are two pairs. The ampulla is simply ovoid or sac-like. The duct is short, about one-third or one-fourth as long and about one-fourth as wide as the ampulla. The diverticulum is single; it

Text-figure 8.



Spermatheca of *Megascoler rodwayi*, sp. n.

arises from the ectal end of the duct, is stoutly club-shaped, the ental end being about as thick as the duct, and extends upwards to about half the height of the ampulla or slightly more.

There are no penial setæ.

Remarks.

The present is one of the more primitive species of the genus (pairing of the setæ, seminal vesicles in ix and xii). It appears to be allied to *M. montanus* Spencer (from Victoria) and *M. minor* Spencer (from Queensland). From the first of these it is distinguished by its much larger size, and by not possessing calciferous glands in segments x, xi, and xii; from the second by its larger size, by its prostomium (that of *M. minor* is epilobous $\frac{1}{2}$), by the position of the glandular patches (in *M. minor* these are mid-ventral on segments x, xi, and xii—possibly, however, the last is a mistake for xx?), in the situation of the first dorsal pore (in *M. minor* this is in furrow 5/6), and in the number of setæ (in *M. minor* 12–16 on each side).

Genus PHERETIMA Kinb.

PHERETIMA PINGI Steph.

Some years ago I described ('25 a) *Pheretima pingi* from a single specimen sent to the British Museum from Nanking by Prof. Ping; one of the chief peculiarities of this species is the possession, in the substance of the wall of the spermathecal duct or projecting on its surface, of a number of small chambers which open into the lumen of the duct. I have recently received a letter from Dr. Y. Chen, Assistant in the Department of Zoology, National Central University, Nanking, in which he gives some additional information concerning this worm, as follows:—

Pheretima pingi is found abundantly in Nanking, where it constitutes about 30 per cent. or more of all earthworms. The example described by me, which was 140 mm. in length, was apparently rather a small one; specimens are usually

190–300 mm. long and 6–8 mm. in diameter. The genital papillæ in the neighbourhood of the male pores are usually, according to Dr. Chen, three pairs, two pairs on xviii and one pair on xix (in my account I described one pair only, behind the setal zone of xviii; this would correspond to the middle of the typical three pairs); the anterior and posterior pairs are not infrequently shifted towards the median line, in which case the two pairs of papillæ on segments viii and ix (present also in my specimen) are shifted inwards to a corresponding extent. In about 20 out of 50 specimens examined by Dr. Chen the papillæ had the more median position, in the rest the more lateral. "Only in one case is there only one pair (middle pair) retained that fits your description. The middle pair, I found, is more constant, while the anterior and posterior pairs are likely to miss in many cases." I take this to mean that either the anterior or the posterior pair of the papillæ of segments xviii and xix is not infrequently absent, but that both these pairs were absent (as in my specimen) only in one out of 50 worms.

PHERETIMA MONTANA (TYPICA) Kinb. (Text-figs. 9–11.)

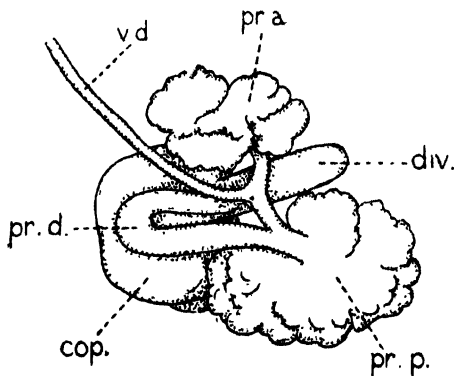
Dunaa, Malekula, New Hebrides. 1929. Miss Cheeseman. A single specimen.

I give a few notes on the single specimen of this interesting species, which differs in several particulars from current descriptions.

The dorsal pores begin in furrow 12/13.

The setæ are larger at the two ends of the body, and are especially large and prominent at the hinder end.

Text-figure 9.



Prostatic apparatus of *Pheretima montana* (typica) Kinb.

cop., copulatory pouch; *div.*, diverticulum of pouch; *pr.a.*, anterior lobe of prostate;
pr.d., prostatic duct; *pr.p.*, posterior lobe of prostate; *v.d.*, vas deferens.

The middle of the transverse slits which constitute the male pores is opposite the 8th seta on each side, and these two points are rather less than one-third of the circumference apart. Five setæ intervene between the two pores.

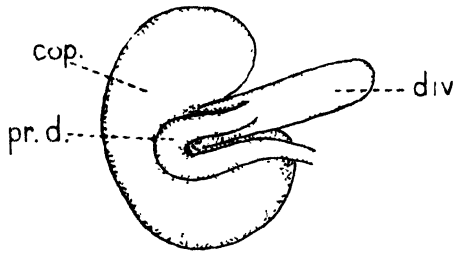
The spermathecal apertures are opposite the 7th seta on each side, or rather less than one-third of the circumference apart.

Septum 4/5 is thin (even in front of septum 4/5 one or two thin septa seem to be distinguishable); 5/6, 6/7, and 7/8 are slightly thickened; 8/9 is very

thin and is perhaps incomplete; 9/10 is absent; 10/11 and 11/12 are somewhat, and 12/13 and 13/14 slightly thickened.

Testis sacs are present in segments x and xi; those of x are unconnected with those of xi, but seem to be themselves connected together across the middle line; those of segment xi seem to be separate, united only by strands of connective tissue, but it is practically impossible to say whether or not such strands

Text-figure 10.

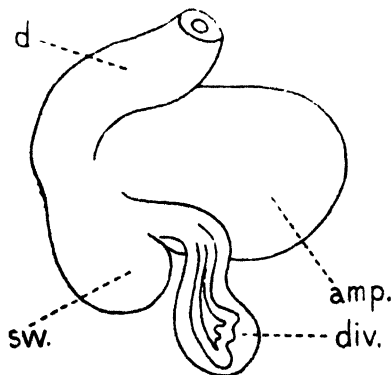


Copulatory pouch and diverticulum of *Pheretima montana*, prostate having been removed, lettering as in text-fig. 9.

represent an empty tubular connection, the cavity of which is indistinguishable owing to there being no coagulum in it. According to Michaelsen ('99), in *Amyntas novaræ* (a synonym of *P. montana*) the two testis sacs of each side communicate, while those of the same segment are separate.

I give an illustration of the very characteristic prostatic and copulatory

Text-figure 11.

Spermatheca of *Pheretima montana*.

amp., ampulla; d., duct; div., diverticulum; sw., swollen ectal end of duct.

apparatus as seen in dissections (text-figs. 9, 10); the copulatory chamber and its diverticulum, when properly cleaned of connective tissue and, perhaps, of nephridial tubules, are irresistibly reminiscent of scrotum and penis.

The spermathecal ampulla (text-fig. 11) is rounded, and adherent to the duct and diverticulum, so that these have to be separated with needles. The duct is much bent, is thicker in its ectal portion, and presents a large one-sided

bulging at its junction with the ampulla ; its total length is equal to that of the ampulla. The diverticulum is single, club-shaped, bent in the form of an S, and enters the swelling on the ental end of the duct ; its total length is equal to that of the ampulla.

PHERETIMA ELONGATA (E. Perr.).

Georgetown, British Guiana ; in soil. 1. iv. 29. L. D. Cleare, Jr. Three specimens. (Imp. Bureau of Entomology, Coll. no. 4316.)

PHERETIMA HETEROCHÆTA (Mich.).

Nowra, New South Wales ; in decaying rubbish-heap in garden. 27. xi. 29. Dr. F. A. Rodway. Two specimens (movements very energetic).

PHERETIMA BIANENSIS, sp. n. (Text-fig. 12.)

Lang Bian Peaks (6000 ft.), S. Annam. Dr. Malcolm Smith. Two specimens, one mature, the other showing male pores, but clitellum not yet developed.

External Characters.

The larger (mature) specimen is 100 mm. long, with a maximum diameter of 5 mm. Colour light brown, the dorsal surface only a little darker than the ventral, the setal ridges whiter. Segments 108 ; faint secondary annulation in a few preclitellar segments of the larger specimen only.

Prostomium epilobous $\frac{1}{2}$, the tongue open behind, its sides slightly converging backwards.

Dorsal pores begin in furrow 12/13.

The setal rings are closed below and show a slight break ($zz=1\frac{1}{4}yz$) in the middle region dorsally, but the break is absent behind, and ceases to exist in front about a quarter of the length of the body from the anterior end, some little distance behind the clitellum. The setæ are more closely set ventrally ; the dorsal setæ of the preclitellar region are notably widely set, very much wider than the ventral. The dorsal setæ of segments v-ix are noticeably large. The following numbers were counted :—32/v, 43/ix, 50/xii, 55/xix, and 59 in the middle of the body.

The clitellum extends over segments xiv-xvi (=3) ; it is smooth, and scarcely differs in colour from the rest of the body ; dorsal pores are present, but no setæ.

The male pores, in the setal zone of segment xviii, appear as transverse slits with corrugated anterior and posterior lips ; they are not prominent in the present specimens, though they may have been so originally. They are very slightly less than one-third of the circumference apart ; on segment xix there are 24 setæ between the two points which correspond to the centres of the apertures ; on xviii, in the mid-ventral region between the apertures, 16 setæ intervene.

The female pore is apparently mid-ventrally situated in the setal zone of xiv, in a small area which is only slightly distinguished from the surrounding region.

The spermathecal apertures are four pairs, not very conspicuous, in furrows 5/6-8/9, rather more than one-third of the circumference apart.

On close examination the accessory glands of the spermathecal region (described below) are seen to be indicated externally by small, round, pigmented spots, brown in colour, in a row immediately behind the spermathecal aperture, i.e., on the anterior margin of the segment behind the pore ; thus five spots

(though only four glands were found internally) occur behind the posterior spermathecal aperture on the right side, and three on the left, one spot on each side in the next anterior segment, and none in relation to the first two pairs of spermathecal apertures.

Internal Anatomy.

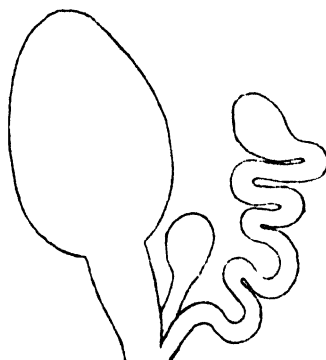
Septum 4/5 is thin, 5/6, 6/7, and 7/8 slightly thickened ; the next is 10/11, which is slightly thickened, as is 11/12, and diminishingly so the next two also. Thus none are much strengthened, 11/12 being, perhaps, the strongest. Some thinning of the septa may have been caused by imperfect preservation.

The gizzard, rather broader behind, is situated behind septum 7/8. The intestine begins in segment xv. The intestinal caeca arise in segment xxvii, and extend forward to xxiv ; they are conical and constricted by the septa, but not otherwise sacculated.

The last hearts are in segment xiii.

The micronephridia are very small and very numerous.

Text-figure 12.



Spermatheca of *Pheretima bianensis*, sp. n. : one accessory gland is shown.

The testis sacs are in segments x and xi ; all four are separate. The seminal vesicles, in segments xi and xii, are moderately bulky (those of segment xii being slightly the larger), take up the whole length of their segments, and approach their fellows dorsally ; they are smooth, and not much lobed ; the vesicles of segment xii, however, have a small separate dorsal lobe, which is slightly indicated in those of xi also.

The prostates are of some size, extending from xvi or xvii backwards to xxi, and are very deeply cut up into lobes. The duct either forms a loop with its curve directed inwards or is S-shaped ; it is muscular and shining, widest in the middle of its course, narrower at both ends ; it terminates in a copulatory pouch which appears as a rounded eminence on the inner side of the body-wall. On this eminence are situated five or six small stalked glands, rather mushroom-shaped, or at any rate thicker at their ental ends. Strong muscular bands pass transversely on the body-wall in front of and behind the copulatory pouch.

The ovaries are in segment xiii : ovisacs are present in xiv.

The spermathecae (text-fig. 12) are four pairs. The ampulla is sac-like, roundish or rather pear-shaped, the ental end the smaller ; the duct is half the length of the ampulla, and narrows towards its ectal end. The diverticulum

joins the extreme ectal end of the duct ; the long, narrow, shining stalk, much twisted or curled, or in part even spirally coiled, ends internally in a small dilated chamber ; the whole diverticulum, when straightened, would be at least equal in length to the ampulla and duct together. A number of accessory spermathecal glands, small, stalked, in length about equal to or somewhat longer than the spermathecal duct, discharge close to some of the spermathecae ; there are none in association with the anterior two pairs, one on each side with the next pair, three on the left and four on the right side along with the posterior pair of spermathecae. One such gland is shown in the figure ; the diverticulum is on the inner side of the spermatheca, and the accessory gland is covered over at its actual end by the spermathecal duct and the stalk of the diverticulum, and does not join either.

PHERETIMA ANNAMENSIS, sp. n. (Text-fig. 13.)

Lang Bian Peaks (6000 ft.), S. Annam. Dr. Malcolm Smith. Two specimens, one much injured in the anterior part of the body, behind the genital region ; both with male pores visible, one with clitellum slightly marked, in the other clitellum absent.

External Characters.

Both specimens are apparently much contracted, the segments being very short. Length of the uninjured, slightly larger specimen 87 mm. ; diameter at middle of body 6 mm., the maximum width, about segments ix-x, being 8 mm. (in the smaller worm these measurements are 5 and 7 mm.). Colour light brown, no difference between dorsal and ventral surfaces. Segments 165 ; no secondary annulation, except that in some of the anterior segments the prominent setal zone is marked off by grooves in front and behind.

Prostomium epilobous $\frac{1}{2}$, marked by a median longitudinal groove ; the tongue open behind.

Dorsal pores begin in furrow 12/13 ; there is a depression in 11/12, but no patent aperture.

The setal rings show no dorsal or ventral break, except that a slight ventral interruption is distinguishable over a short tract behind the male pores, and also in a few segments near the anterior end. The setae are somewhat larger in segments iii-ix and at the hinder end ; they are not set notably closer at one part of the circuit than another. The following numbers were counted :—72/v, 82/ix, 90/xii, 90/xix, and 71 in the middle of the body.

The clitellum extends over segments xiv-xvi (=3) ; no setae are visible in this region, but dorsal pores and intersegmental furrows are still present, as well as the furrow in front of the setal ridge of xiv, and there is no alteration of colour ; but quite possibly the clitellum is not yet fully developed.

The male porophores are large circular papillae, with smooth sides, which take up the whole length of segment xviii and even cause a bulging apart, in front and behind, of the intersegmental furrows. On the surface of each porophore is a large circular opening with a corrugated lip ; behind the aperture, on its lip, is seated a small secondary papilla, and within the aperture is seen a smooth, rounded, dome-like elevation which, coming up to the level of the aperture, occupies almost the whole opening. The two porophores are joined across the mid-ventral line by a smooth glandular tract ; four setae intervene between them in this region, and the apertures are distant from each other one-sixth of the circumference. In the less mature specimen the appearances are less characteristic.

The female and spermathecal pores are not visible ; from the internal anatomy the spermathecae open in furrow 6/7, not far from the middle line,

and probably (if indeed there are a pair, *v. inf.*) not more than one-sixth of the circumference apart.

There are no other genital markings.

Internal Anatomy.

Septa 5/6, 6/7, and 7/8 are all considerably thickened, 8/9 and 9/10 are absent, 10/11–13/14 somewhat thickened, and the next two slightly so.

The gizzard—large, firm, subspherical—is situated behind septum 7/8. The intestine is in segment xv. Intestinal cæca are absent.

The last hearts are in segment xiii.

The micronephridia are very numerous and small, and are scattered all over the body-wall. Tufted nephridia are present in segments v and vi.

The testis sacs in segment x include the hearts, and extend round the alimentary tube towards the dorsal side; they communicate with each other ventrally. I found no testis sacs in segment xi, though well developed seminal vesicles were present in xii, and it is a question, therefore, where the contents of these vesicles came from.

Text-figure 13.



Spermatheca of *Pheretima annamensis*, sp. n.

The seminal vesicles, rather large in size, occupy segments xi and xii; the vesicles of segment xi are for the most part fairly smooth, massive, and not much cut up into lobes, but presenting a small portion at their dorsal end which is very much lobulated and cauliflower-like; in xii the ventral part of each vesicle is similarly massive and only slightly lobed, while the much cut up and cauliflower-like dorsal portion is of considerable size.

The prostates are kidney-shaped and small, and probably not fully developed; the surface is cut up into fine lobules. The duct is short and relatively stout, shining, with a single bend—forwards on one side, backwards on the other—with no sign of a copulatory pouch as seen from inside, though possibly the pouches have been everted and form the papillæ seen externally.

The ovaries are small in segment xiii.

Only one spermatheca was seen (text-fig. 13), small and probably immature, on the left side, opening in furrow 6/7 not far from the ventral nerve-cord. The ampulla is small and ovoid, the duct about as long and not very far from as wide as the ampulla; the diverticulum is a small rounded excrescence, sessile on the outer side of the duct at about the middle of its length.

PHERETIMA HUPBONENSIS, sp. n. (Text-fig. 14.)

Hup Bon, S.E. Siam. 1. x. 24. Dr. Malcolm Smith. A single specimen, much softened, which broke in two under examination.

External Characters.

Length 225 mm.; maximum diameter 9 mm. (at clitellum). Colour an equable fairly light brown. Segments 142; some preclitellar segments

faintly triannulate (the secondary annulation may have been more distinct before the specimen became softened).

Prostomium unrecognizable.

Dorsal pores begin in furrow 11/12.

The setal rings show no ventral break, and only a very small dorsal interruption ($zz = 1\frac{1}{4} - 1\frac{1}{2} yz$). The setæ of segments ii–ix are enlarged; the ventral setæ are rather more closely set than the dorsal. The following numbers were counted:—32/v, 45/ix, 54/xii, 68/xix, and 74 in the middle of the body.

The clitellum, extending over segments xiv–xvi (=3), is ring-shaped, slightly swollen, smooth, and of a darker brown in colour, without setæ, but showing small dorsal pores.

The male apertures, on xviii, are situated each in a large sucker-like area, with a raised rim; within the rim the enclosed area is flat and slightly depressed, and the whole extends from near the setal zone of xvii to near that of xix; the interval in the middle line between the rims of the two areas is small, less than half the diameter of one of the areas. The male pores are within the rim, on the outer part of each area, and each is overhung by a small papilla (perhaps the everted copulatory pouch); the pores are about a quarter of the circumference apart, and eight setæ, situated on the rim of each area and in the intervening space, occupy the region between the pores.

The female pore is single, in a whitish transversely oval area, in the setal zone of xiv.

The spermathecal apertures are two pairs, transverse slits, each with a swollen and corrugated anterior lip, in furrows 7/8 and 8/9. They are a quarter of the circumference apart; on segment ix nine setæ intervene between the lines of the pores.

There are no other genital markings.

Internal Anatomy.

Septum 4/5 is slightly strengthened, 5/6, 6/7, and 7/8 somewhat more so—not much, however, for so large a worm; 8/9 and 9/10 are wanting; 10/11 is slightly, 11/12 and 12/13 somewhat more, and the next two septa slightly thickened.

The gizzard, behind septum 7/8, is firm and barrel-shaped. The intestine begins in xv; the cæca originate in xvii, are narrowly conical and tapering, with a smooth outer surface, their inner surface presenting a large number of small sacculations, and thus appearing coarsely crenulated. A special peculiarity of each cæcum consists in the presence along the whole extent of the lower border of a series of secondary diverticula, 12–13 in number, those towards the base of the cæcum being conical in shape, those towards the apex becoming gradually shorter, and finally, near the tip, merely knob-like; the larger secondary diverticula near the base of the primary cæcum are themselves irregular in contour, with small tertiary evaginations.

The last hearts are in segment xiii.

The micronephridia are numerous and small; tufted nephridia are present in iv, v, and vi.

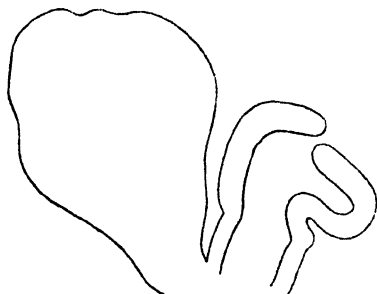
Testis sacs are present in segments x and xi; as seen in a dissection from the ventral side, the two sacs of a segment are separate, those of the same side continuous. The seminal vesicles, in segments xi and xii, are large, and project dorsally so as to reach the dorsal vessel; their anterior margin is slightly lobed, the posterior margin scarcely at all; the whole surface is marked out into small lobules.

The prostates, large and cut up into lobes, occupy segments xvii–xix, and encroach on segments xvi and xx by pressing septa 16/17 and 19/20 forwards and backwards respectively. The duct—short, soft, shining slightly—leaves the middle of the gland and forms a short transversely-placed loop, of which the two limbs lie one above the other (in the position of dissection), the lower or ectal limb being the shorter and rather stouter. No copulatory pouch is to be seen in dissection, but an everted pouch is perhaps represented by the papilla externally.

Ovaries were not identified, and are apparently absent in this specimen.

The spermathecae (text-fig. 14) are two pairs; the ampulla is a simple,

Text-figure 14.



Spermatheca of *Pheretima huphonensis*, sp. n.; a second diverticulum is shown, to illustrate its variable curve.

loose-walled, irregular sac, and there is no duct, since the sac merely narrows towards the body-wall, which it enters at its base. The single diverticulum is elongated and cylindrical: its ectal third is narrower than the rest and shining, constituting a duct, and joining the base of the sac where the latter enters the body-wall; the diverticulum, with its duct, may be straight, or may form a single curve, or may be bent on itself twice; its total length when straightened out is less than that of the ampulla.

Genus PERIONYX E. Perr.

PERIONYX SETNAI, sp. n.

Darjeeling. S. Setna. Three specimens, sexual.

External Characters.

Length 85–130 mm. Diameter 3–3.5 mm. Colour a medium grey, the same on both dorsal and ventral surfaces; no dorsal stripe. Segments of the longest specimen 124; no secondary annulation.

Prostomium epilobous $\frac{1}{2}$, tongue not cut off behind.

Dorsal pores begin in furrow 4/5.

The setae are arranged in rings; the dorsal break is irregular and small, its average extent being equal to $1\frac{1}{2}$ yz; a ventral break is not, or scarcely, distinguishable. The setae are more closely set ventrally; in one specimen they are particularly closely set in the lateral regions of segment xii, but this was not markedly so in the others. The following numbers were counted:—55/v, 55/ix, 68/xii, 47/xix, and 44 in the middle of the body.

The clitellum includes segments xiii– $\frac{1}{2}$ xvii (=4 $\frac{1}{2}$); it is not very sharply defined, and is of a darker grey than the general surface; setae are present, but the dorsal pores are not patent.

The male field is a sharply defined deeply sunk rectangular depression half as wide again as long, situated mid-ventrally on segment xviii; it takes up the whole length of the segment; its floor is flat. The male apertures are small, on the floor of the depression near the middle line.

The female pore is single, on segment xiv between the setal ring and the anterior border of the segment.

The spermathecal apertures are two pairs, in furrows 6/7 and 7/8, moderately close together, but not quite as close as the male apertures.

There are no other genital markings.

Internal Anatomy.

Septa 4/5 and 5/6 are thin, 6/7 is slightly thickened, and so are all as far back as 10/11 or, perhaps, somewhat further.

The gizzard, very small and vestigial, is in segment v. There are no calciferous glands. The intestine begins behind the prostates, in segment xix.

The last hearts are in xii; the nephridiopores are approximately in the same line on each side.

The testes and funnels are free, in segments x and xi. The seminal vesicles, in xi and xii, appear as large flocculent masses, fused in the middle line, and taking up the whole of the available space in their segments. In one specimen, but not in a second, there appeared to be in segment xiii a small pair of accessory seminal vesicles, which, however, on teasing showed only some granular amorphous material in their interior.

The prostates are small and confined to xviii, compact in form and only slightly cut up into lobes. The ducts are short, thin and soft, and bent (forwards on one side and backwards on the other): the ectal portion is rather wider than the ental.

There are no penial setæ.

Ovaries and funnels are present in segment xiii.

The spermathecae, in segments vii and viii, are of very simple form—moderate-sized regularly ovoid sacs lying on the body-wall, and each communicating with the exterior by a short wide duct; there is no diverticulum.

Subfamily *DIPLOCARDIINÆ*.

Genus *DICHOGASTER* Bedd.

DICHOGASTER BOLAU (Mich.). (Text-fig. 15.)

Ingyindaung, Burma (right bank of Chindwin River, 76 m. by boat from Pakokku, and thence 20 m. inland). Prof. G. E. Gates. A single specimen.

Rangoon. Prof. G. E. Gates. Fourteen specimens.

Maungmagaun, Burma (on sea-shore, near Tavoy). Prof. G. E. Gates. A single specimen.

Kavieng, New Ireland; from the vagina of a native woman. Dr. E. J. Ryan (through the Australian Institute of Tropical Medicine). Two specimens, one very small and immature, the other with sexual marks.

In the specimen from Ingyindaung the gizzards appeared to be undoubtedly in segments xi and vii, or one segment in front of the usual position, while the single pair of seminal vesicles were in xii, one segment behind the normal. Ovisacs were present in segment xiv.

The penial setæ were rather larger than previously described ; the toothed form was 0·4 mm in length, with four or five visible spines, the spatulate form

Text-figure 15.



Flattened tip of penial seta of *Dichogaster bolani* (Mich.), with one thickened and one thin edge.

0·33 mm. long. The second kind of penial setæ, with expanded tip, may be asymmetrical (the flattened portion having one thicker and one thin and flattened edge) (text-fig. 15).

DICHOGASTER MODIGLIANII (Rosa).

Mergui Burma. Prof. G. E. Gates. Nine specimens.

Rangoon. Prof. G. E. Gates. Two specimens.

Maungmagau, Burma (on sea-shore near Tavoy) Prof. G. E. Gates. A single specimen.

DICHOGASTER SALIENS (Bedd.).

Maymyo, Burma. Prof. G. E. Gates. Four specimens all sexual.

Lashio, Burma. Prof. G. E. Gates. Two specimens, both sexual.

The worms from Maymyo are, I think, to be identified as *D. saliens*, though there are a few differences from previous descriptions. Thus the prostomium is apparently prolobous (not tanylobous). The dorsal pores begin in furrow 5/6 (not 4/5). The clitellum, including segment xiii in front and the greater part of xx behind, is saddle-shaped over segments xix and xx, and at first also on xiii, while over the remaining segments it is ring-shaped (in *D. saliens* its extent is xiii-xix, and it is saddle-shaped). The marking in the situation of furrow 15/16, described as a pit in *D. saliens*, appears as a faint whitish oval area with a slightly darker centre, and, as usual, is not visible in all specimens. The nephridia are in four rows, instead of the more usual five. The penial setæ are all of the same size. There were no testis sacs (these are doubtfully recorded in *D. saliens*). The penial setæ were of one size only (a difference in size has been noted in *D. crawi*, but not in *D. saliens*); the "teeth" on the undulations of the distal portion of the shaft are few and faint—only three as seen with the oil-immersion lens—and confined to the terminal one or two undulations.

Before discussing the specimens from Lashio it will be better to give a description :—

External Characters.

Length 17–19 mm. (much shorter than the specimens from Maymyo, of which the largest was 44 mm., and smaller specimens 31 mm. in length);

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maximum diameter 2 mm. Colour a rather pinky flesh-colour, the same on dorsal and ventral surfaces; clitellum rather darker, purplish. Segments (of the longer) 73 (as against 120 in the largest example from Maymyo); a few segments in front of the clitellum triannulate. A faint medio-dorsal pigmented stripe.

Prostomium proepilobous, with semicircular posterior border; a median groove continued back through segment i; segments i and ii only faintly demarcated.

Dorsal pores begin in furrow $4/5$, in which the pore is small; in $5/6$ a large patent pore.

Setæ paired rather closely; in the middle of the body and at the hinder end aa is slightly less than bc or often about equal, and $dd = \frac{5}{8}$ of the circumference; in front of the clitellum aa is definitely less than bc , and $dd = \frac{2}{3}$ of the circumference (in the specimens from Maymyo dd diminishes in front of the clitellum, where it is actually less than $\frac{1}{2}$ of the circumference). The ventral pairs are slightly closer together in the region of the male pores (though this was not noticed until it was specially looked for), but not in the spermathecal region.

The clitellum includes xiii in front and two-thirds of xx behind, and is saddle-shaped. I do not think the clitellum can be called anything else than saddle-shaped, though the lower margins of the clitellum are very indistinct; it is just possible that at a more advanced stage of development, if such occurs, it might be described as ring-shaped but less developed ventrally.

The male area shows a pair of short longitudinal slits, almost straight or slightly sinuous, in line with setæ a , on segment xvii; these have the appearance of cutting deeply into the tissues. These grooves are situated in an area of subcircular shape, rather broader than long, which is circumscribed by a very definite groove—the groove wanting, however, in the middle line posteriorly; the area extends anteriorly to somewhat behind the level of the setæ of xvi, and behind to about the level of the setæ of xviii, and it is divided into two by a median longitudinal groove. While the anterior ends of the slits which represent (or connect) the male and prostatic pores are at the level of the setæ of xvii, the posterior ends of the slits stop short of the level of the setæ of xviii. Expressed otherwise, to bring the description more into line with those of allied species (*v. post.*), two male papillæ might be described, each semicircular in shape, the straight bases of the semicircles abutting on each other in the mid-ventral line; these papillæ are low, scarcely rising above the general level, but are marked off at their circumference by a distinct groove; they take up segment xvii along with the hinder part of xvi and anterior part of xviii. The male (or male and prostatic) apertures appear as each a longitudinal slit in line with setæ a , on segment xvii.

The female pores are on xiv, a little internal and very slightly posterior to setæ a ; there are faint grooves in the form of parentheses on each side of the female area.

The spermathecal apertures are not visible externally.

Internal Anatomy.

Septum $4/5$ is somewhat strengthened, and also a few in the region of the anterior male organs. Apparently one or more septa are absent in the region of the gizzards.

There are two well developed gizzards in segments vii and viii. Calciferous glands are present in segments xv, xvi, and xvii.

The last hearts are in xii.

The nephridia are in four longitudinal rows on each side, or occasionally there are five on one side of a segment; the more ventral nephridia (except the fifth, when present) are not notably smaller than the more dorsal.

I did not see any sign of testis sacs in segments x and xi; the presence of testes and funnels was concluded from the iridescent masses (of spermatozoa). In xi and xii are the minute seminal vesicles, those in xii being distinctly racemose. There is a single pair of prostates in xvii, of relatively moderately large size, rather sharply bent more than once; the prostatic duct is narrow and sinuous, half as long as the glandular part; the ectal portion of the vas deferens is thick and shining, as thick as the prostate as it passes backwards to enter the body-wall behind the ending of the latter.

The ovaries are in xiii, and ovisacs are present in xiv.

The spermathecae are two pairs, near the middle line, and apparently discharging in furrows 7/8 and 8/9; the ampulla is rather broad and sac-like, very distinctly marked off from the duct, all round the ental end of which it projects and overhangs; the duct is longer than the ampulla, but only half as wide or less, constricted where it joins the ampulla, but for the rest cylindrical; the single diverticulum is smooth and regularly spherical (or slightly oval), and attached by a stalk to the duct above its middle; in the ampulla are a number of acicular crystals.

The penial setae, two per bundle, differ slightly; the longer of the two is 0.68 mm. in length, $13\ \mu$ thick near the base, slightly bowed, tapering gently and rather irregularly sinuous towards the free end; the tip is rather suddenly narrowed to an almost hair-like fineness, the termination being very slightly thickened or knobbed. The shorter seta is 0.51 mm. in length and $8\ \mu$ thick near the base—quite evidently of slighter build than the former; the shaft is almost straight, there is scarcely any sinuosity, and the tip is suddenly contracted as before, ending, as in the larger seta, in a minute knob. The tip of the setae may be variously bent—in a quadrant of a circle or in the form of a crook—or it may merely continue the direction of the shaft. In the larger variety, at least, there are a few faintly marked transverse ridges near the distal end, on the convexities of the sinuosities, but on one side of the shaft only.

Remarks.

I have found it difficult to decide whether to assign the specimens from Lashio to *D. saliens* or *D. crawi*. Eisen ('00) states that in *D. crawi* "the very diminutive segment i is entirely hidden," whereas here it is of quite moderate size, though it is only faintly demarcated from segment ii (as is the case in *D. saliens*). The prostomium is (? pro-) epilobous in *crawi*; in *saliens* it is tanylobous, but the tongue is narrow; in the present specimens the longitudinal groove on the dorsum of segment i corresponds to this narrow tongue, and is to be regarded as produced by the further approximation of the furrows bounding the tongue on each side. The dorsal pores begin in the present specimens, as in *D. saliens*, in 4/5 (in *crawi* in 3/4). With regard to the setae *D. crawi* is stated by Eisen to have the ventral couples closer together in the region of the male pores, and less distinctly also in the spermathecal region in the present specimens they are slightly closer together in the region of the male pores, but not in the spermathecal region. The clitellum, being saddle-shaped, resembles that of *saliens* rather than that of *crawi* (ring-shaped); in extent it agrees exactly with neither species. The male area agrees pretty closely with that of *D. saliens*, which is described by Michaelsen ('03) as follows:—Prostatic pores "one pair, in the setal zone in line with setae a, in the middle

of large halfmoon-shaped papillæ which take up xvii and the anterior fourth of xviii, the flat sides meeting in the middle line. Male pores [*i.e.*, openings of the vasa deferentia, which I did not see] also on these papillæ, just in front of the hinder margin, in 17/18, connected with the prostatic pore by a straight comma-shaped seminal groove, running from in front backwards, which cuts deeply into the papilla." The transverse pit in furrow 15/16 of *D. saliens* was not seen in these specimens (nor was it invariably present in Michaelsen's).

Internally, septum 4/5 is noted as being thickened in *crawi* (as here), but not in *saliens*. The number of nephridia (four longitudinal rows on each side in *crawi*, more usually five in *saliens*) corresponds here rather with that characteristic of *crawi*. The spermathecae resemble those of *crawi* rather than those of *saliens*, though the differences between all three are not very great; here the general proportions are as described for *crawi*, except that there is no swelling of the ental end of the duct; in *saliens* the ampulla would seem to be smaller and more regularly ovoid, the duct relatively longer, and the diverticulum narrowly pear-shaped. Two sizes of penial setæ are indicated in *crawi* in Eisen's figure, and are definitely referred to by Michaelsen ('13) in *crawi*, but not ('03) in *saliens*; in Eisen's figure the thin bent tip of the seta is shorter in the larger than in the smaller kind (as seems to be the case in my specimens), while the sinuosity is more marked in the larger (as also in mine). Michaelsen ('00) distinguishes the penial setæ of the two species by the presence in *saliens* in the sinuous part of the seta of definite scale-like prominences at each bend, absent in *crawi*; again ('03) the stout, blunt projections of the setæ of *saliens* are contrasted with two series of alternating ridges, one series on each side of the shaft and each ridge corresponding to a groove on the opposite side, which characterize the setæ of *crawi*; of the two, the penial setæ of the present form resemble more closely the descriptions of those of *crawi*.

Thus, in the matter of the prostomium and segment i, the dorsal pores, clitellum, and configuration of the male field, the specimens resemble *saliens* more than *crawi*; in the septa, nephridia, spermathecae, and penial setæ the resemblance is rather to *crawi*. Both *D. crawi* and *D. saliens* have previously been recorded from the Indian area, the former by me, the latter by Michaelsen.

I did not, when I met with the worm which I identified ('20) as *D. crawi*, give any description, but contented myself with recording its occurrence. I have referred back to my notes, and find that it certainly belongs to the same species as the worms which I have described above. The prostomium is noted as being proepilobous, segment i as being short and not very distinct from segment ii: the anterior limit of the dorsal pores was not certainly determined; *aa* was slightly greater than *bc*; the clitellum extended over xiii- $\frac{1}{2}$ xx and was saddle-shaped (this was subsequently modified—"or rather, thinner along a mid-ventral tract"); the configuration of the male area was similar to that of the present specimens, and a "quite marked," small, darkish depression was present mid-ventrally in 15/16 (a characteristic of *D. saliens*). Septum 4/5 was somewhat strengthened; there were five longitudinal rows of nephridia on each side, the innermost of the five being much the smallest; the prostates were exactly as in the present specimens; ovisacs were present in xiv; the spermathecae were slenderer, both ampulla and duct; only one kind of penial seta is described, and no scale-like teeth are mentioned or figured.

It seems doubtful whether *crawi* and *saliens* can be retained as separate species. The differences in the prostomium and first segment would be explained by supposing that in the original specimens of *D. crawi* this region was strongly retracted; the differences in the clitellum and male field may be ascribed to different degrees of development and of contraction of the internal muscular

bands in the region of the male apertures ; the pit in furrow 15/16 is not always present even in *D. saliens* ; while the differences in the dorsal pores, setal relations, and several details of internal anatomy come, I think, within the limits of individual variability, and are not such as could be used to differentiate species. There remains the question of the penial setæ ; there is not, perhaps, very much difference between the coarse scale-like teeth of the one and the series of short ridges of the other ; the curve of the tip is certainly not always the same ; while for some reason or other the smaller variety of penial seta may not have been obtained by Michaelsen when examining his specimens of *D. saliens*. The specimens, both from Maymyo and from Lashio, which I have recently examined, as well as those I had formerly (from Darjiling District), seem to show that there are intermediate conditions in the case of several of the alleged differences between the two species, or that some characteristics of the one may exist along with others of the other species. I believe, therefore, that the two must be united, and that the name *crawi* ought to disappear.

DICHOASTER CURGENSIS Mich. var. *UNILOCULARIS*, var. n. (Text-figs. 16 & 17.)

Lashio, Burma. Prof. G. E. Gates. Two specimens, both with marks of sexual maturity.

External Characters.

Length of the longer specimen 30 mm. ; diameter 2 mm. Colour pinkish, flesh-colour ; clitellum purple. Segments 92 : no secondary annulation ; segment i not notably small, but the furrow behind it is not distinct.

Prostomium epilobous $\frac{1}{2}$, the tongue cut off behind.

Dorsal pores begin in furrow 5/6.

The setæ are paired, from behind the clitellum to the hinder end *aa* is slightly greater than *bc*, while *dd* is nearly (or even quite) $\frac{2}{3}$ of the circumference ; but the ratio varies a little here and there, and *aa* may in many places be no greater than *bc*. In front of the clitellum *aa*=*bc*, and *dd*= $\frac{2}{3}$ of the circumference.

The clitellum, on segments xiii-xx, is ring-shaped, and is present ventrally on segment xiii as well as the other segments.

The prostatic pores are situated on segments xvii and xix, in line with setæ *a* ; the seminal grooves are almost straight, slightly convex inwards, and the aperture of the vas deferens on each side is apparently in the groove at the middle of its length. The pores and grooves are contained in a rectangular or somewhat pentagonal depressed area ; the anterior and posterior limits of the area are formed by grooves, transverse or, in the case of the anterior, curved forwards (so giving the resemblance to a pentagon), which extend between the two prostatic pores of the same segment ; the lateral margins are shelving, and are situated a little external to the seminal grooves.

The female apertures are possibly just internal to the setæ *a* of segment xiv.

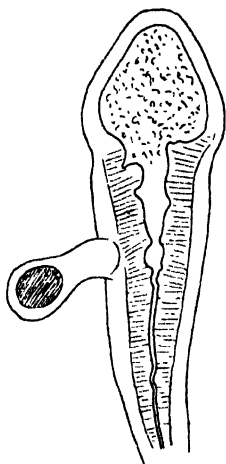
The spermathecal apertures are not visible.

Internal Anatomy.

Septum 5/6 is thin ; 6/7 does not seem to be a complete septum, but appears to be represented by connective tissue strands and perhaps muscular bands which pass from the gizzard to the periphery ; the rest of the septa are all present, and as far as 12/13 are (though really not strong) thickened somewhat in comparison with those further back, which are hardly distinguishable.

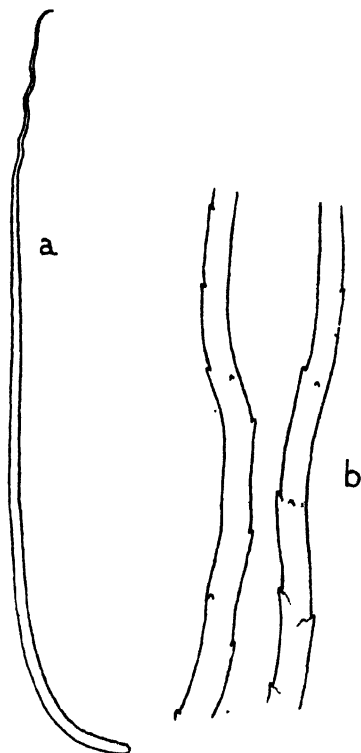
The two gizzards, in vi and vii, appear together as a rectangular organ

Text-figure 16.



Spermatheca of *Dichogaster curgensis* Mich. var. *unilocularis*, var. n.

Text-figure 17



Penial setae of *Dichogaster curgensis* Mich. var. *unilocularis*, var. n.
 a, whole seta, $\times 120$; b, portions of the shaft near the distal end, $\times 1600$.

rather longer than broad, and divided across the middle by a slight and narrow ridge, into which the strands representing septum 6/7 are inserted. There is no constriction or soft ring between the gizzards. Calciferous glands are present in segments xv, xvi, and xvii, the anterior pair fully equal in size to the others.

The last hearts are in segment xii.

The nephridia are five on each side in each segment, the lowest of the series being the smallest.

Testes and funnels are free in segments x and xi (as evidenced by the presence of iridescent masses of spermatozoa). No seminal vesicles were seen. The ovaries and female funnels are large in segment xiii.

The spermathecae (text-fig. 16) are two pairs, situated near the middle line. There is no external separation between the ampulla and duct: the whole apparatus forms an elongated organ, broader above, its ental end being bluntly pyramidal. The upper half of the organ represents the ampulla; its cavity is broad above, narrower below owing mainly to an increased thickness of the wall, especially of the epithelium of the wall. The duct has a narrow canalicular lumen, is as long as the ampulla, and narrows somewhat downwards. The diverticulum consists of a seminal chamber and a short stalk, and joins the lowest part of the ampulla: in the example which is represented in text-fig. 16 the chamber is single, and from this circumstance I gave the varietal name (*unilocularis*); but on examining carefully a second example of the organ I found there, apparently, a second, though empty, chamber in addition.

The penial setæ (text-fig. 17) are 0.81–0.84 mm. in length, with a diameter of $6.5\ \mu$ at the middle of the shaft and $9\ \mu$ near the base. The shaft is slightly bowed, the distal portion tapering, and gently and irregularly sinuous: the tip is still $1\ \mu$ thick, not hair-fine, and not knobbed: on the sinuous portion of the shaft—about the distal third—are a number of very minute tooth-like prominences, which are more frequent than the undulations of the shaft.

Remarks.

The features in which the present specimens differ from the type form of the species are: (i.) the smaller extent of the dorsal interval *dd* (three-quarters of the circumference in the type form): (ii.) the situation of the first dorsal pore (in the type form these are evident from 11/12 onwards, though, perhaps they actually begin further forwards): (iii.) the clitellum, which in the type form is thinner below: (iv.) the more numerous nephridia: (v.) the penial setæ, which in the type form have a double sinuosity, a larger superimposed on a smaller and finer, and a scar and tooth at each bend of the finer sinuosity: (vi.) the spermathecal diverticulum, which in the type form joins the upper end of the duct, and contains three or four seminal chambers.

DIOHOGASTER ESCA, sp. n. (Text-fig. 18.)

Begoro, Akim, W. Africa. April 1930. F. R. Irvine, Achumota College, Gold Coast. Two specimens, both with sexual marks.

The finder states:—"It comes out in great numbers after rain, and is bright red when fresh. It is used as a bait in fishing." The specific name is taken from the latter circumstance.

External Characters.

Length 120–130 mm.; diameter 4.5 mm. Colour light olive or brownish olive; ventral surface rather lighter. Segments 213; in the anterior segments,

as far back as the clitellum, the setal zones are raised in the form of whitish rings.

Prostomium a large and prominent rounded lobe ; one specimen is zygo-bous, the other, showing a slight groove which delimits the prostomium behind, prolobous.

Dorsal pores begin in furrow 15/16 ; or (in the second specimen) in 18/19, with, perhaps, a rudimentary non-patent pore in 17/18.

The setæ are paired, and are all situated ventrally ; in the middle of the body $ab = \frac{1}{2} aa = \frac{2}{3} bc$, and is rather greater than cd , while $dd = \frac{2}{3}$ of the circumference ; towards the hinder end the setæ are rather more prominent, and, being not quite so closely paired, $ab = \frac{1}{4} aa = \frac{1}{3} bc$, and, as before, is rather greater than cd , while dd is perhaps rather less than two-thirds of the circumference ; in front of the clitellum aa becomes relatively (but only relatively) greater, so that $ab = \frac{1}{6} aa = \frac{1}{3} bc$ or nearly, while dd is greater than before, almost three-quarters of the circumference. Thus, in the specimen just described aa is throughout noticeably larger than bc , especially in front ; in the other specimen aa and bc are more nearly equal, though a slight difference is always perceptible ($ab = \frac{1}{4} aa = \frac{2}{3} bc$).

The clitellum can only be distinguished ventrally, where it is represented by a smooth swollen area extending over $\frac{1}{2}$ xvi-xx ($= 4\frac{1}{2}$), and almost reaching the lateral setæ on each side ; the corners of this swollen area are truncated, so that its outline is barrel-shaped. The lateral setæ are, of course, visible in this region, since the swollen area does not extend so far ; the ventral setæ are also either visible or indicated by pits, but those of xviii are not to be made out. The setal zones (seen as whitish rings) of segments xvii and xviii are closer together than any others.

The prostatic pores are possibly in the setal zones of xvii and xix, rather outside the line of setæ b ; the sites of the setæ ab of these segments seem to be a little more opaquely white than the rest of the clitellum, and these opaque areas spread somewhat outwards towards cd . The apertures of the vasa deferentia are, perhaps, just visible, in a corresponding position on xviii. The swollen ventral area is marked by a few slight and irregular furrows, but no seminal grooves are to be seen.

The female pores are possibly in the setal zone of segment xiv, between the setæ a .

The spermathecal pores, in furrows 7/8 and 8/9, are on small papillæ in line with setæ b ; the two pores of each pair are connected across the middle line by a narrow, slightly opaque strip, which may be hollowed into a shallow transverse groove. In one specimen the area included between the four spermathecal pores is somewhat thickened and opaque.

A number of genital markings are present as small transversely elongated mid-ventral papillæ in furrows 10/11-14/15 ; in one specimen there seems to be an extra papilla, or possibly only an accidental mark, rather in front of furrow 13/14 on the right of the middle line, its centre in line with seta a .

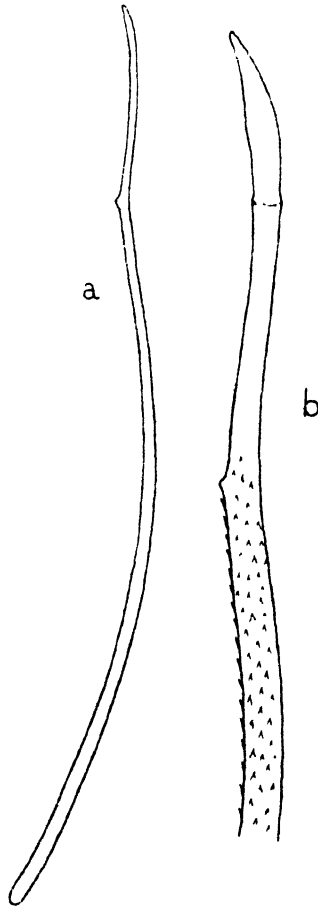
Internal Anatomy.

Septum 4/5 is strong ; 5/6 is considerably thickened, but not as much so as 4/5, and is attached at the level of furrow 6/7 ; septum 6/7 is attached at the level of the setal ridge of segment ix, 7/8 at that of x, 8/9 a little behind furrow 10/11—these three being somewhat strengthened ; septum 9/10 is attached at the level of furrow 11/12, 10/11 and 11/12 are attached on segment xii, septum 11/12 a little anterior to furrow 12/13 ; septum 12/13 is attached

at the level of the setal zone of xiii ; there is some faint thickening of the septa as far back as 13/14.

There are two large firm gizzards, in v and vi, each with a length of soft and flaccid œsophagus in front of it ; the anterior gizzard is shortly barrel-shaped, the posterior shortly cylindrical. The calciferous glands, in xiv, xv, and xvi, appear as opaquely white kidney-shaped organs, attached to the alimentary

Text-figure 18.



Penial setæ of *Dichogaster esca*, sp. n.
a, whole seta, $\times 50$; b, distal end, $\times 140$.

tube by the hilus ; those in xv are the largest, and the margins of those in xvi are lobed. The intestine begins in xvii.

The last hearts are in xii.

The micronephridia are numerous and very small, arranged in transverse rows in front of the septa. Towards the hinder end the ventralmost nephridium of the row on each side increases greatly in size, and occupies the interval, on the inner surface of the body-wall, between the lines of the ventral and lateral

setal sacs ; under the microscope a large part of the bulk of the organ is seen to consist of large, clear, vacuolated cells.

Testes and funnels, of considerable size, are present in segments x and xi. The seminal vesicles, in xi and xii, are small and irregularly lobed. The tubular prostates are two pairs, in xvii and xix ; the ental portion is composed of loosely apposed loops, not all lying in the same plane, and the organ is prolonged inwards (ventralwards) as a straighter tube with only one or two slight bends in its course, the ectal end, representing the duct, being somewhat thicker than the rest and spindle-shaped ; this straighter portion is about as long as the convoluted ental part (in its natural condition, without unwinding). The two vasa deferentia of each side are easily seen on the body-wall, running closely side by side : they pass underneath (in this position) the spindle-shaped terminal portion of the anterior prostate and, still separate, enter the body-wall in line with the endings of the prostates, but nearer the anterior than the posterior prostate. The ectal portions of the vasa deferentia are also somewhat thickened. Large penial setal sacs cover over the greater part of the straight portion of the prostates.

The ovaries and funnels are small in xiii.

The spermathecae are two pairs of small, irregular, sessile sacs, the ducts being entirely contained within the body-wall ; there is no diverticulum, since the irregular bulgings of the sac-wall cannot be described as such. The setae of the spermathecal region are not modified.

The penial setae (text-fig. 18) are numerous and in large bundles. They are 2.15–2.3 mm. long, their thickness near the base is $33\ \mu$, at the middle of the shaft $27\ \mu$; the shaft is gently bowed, and tapers gradually towards the tip, which is bluntly pointed and slightly clawed. The most noticeable feature, one which strikes the eye immediately, is a shoulder or thick blunt spine on the shaft, at a varying distance— 340 – $520\ \mu$, one-fourth to one-sixth or one-seventh of the whole length of the seta—from the tip ; the curve of the seta alters its direction slightly at this projection, which thus becomes a sort of angle on the shaft. The terminal portion of the shaft close to the tip may be slightly expanded (as shown in the figure) and there is usually a faint and narrow annular thickening, like the joints on a bamboo, at some level between this expansion and the shoulder. A fine ornamentation of numerous small triangular spines, irregularly arranged, extends over a considerable length of the shaft, from the region of the shoulder proximalwards, becoming fainter and ultimately indistinguishable somewhat proximal to the middle of the length of the shaft ; the spines are more numerous on the sides and concave surface of the shaft, being seen in silhouette as projections in the latter situation, whereas none are visible in silhouette on the convex border.

DICHOASTER SINUOSUS, sp. n. (Text-fig. 19.)

Labaw (on the Tavoy–Mergui road, ca. 63 m. from Tavoy). Prof. G. E. Gates. Three specimens.

Ingyindaung (on right bank of Chindwin River, 76 m. by boat from Pakokku, and thence 20 m. inland). Prof. G. E. Gates. A single specimen.

Lashio (N. Shan States), Burma. Prof. G. E. Gates. A single specimen.

Maungmagaun (on sea-shore near Tavoy). Prof. G. E. Gates. A single specimen.

External Characters.

Length 27 mm. ; diameter 1.75 mm. (clitellar region rather broader, 2 mm.). Colour a rather light grey, clitellum darker. Segments 105.

Prostomium proepilobous ; a dorsal groove continued back from hinder border of prostomium through segment i. In the specimen from Maungmagaun segment i is rather short, and the furrow between i and ii is very slightly marked.

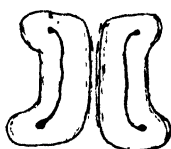
Dorsal pores begin in furrow 5/6.

The setæ are closely paired, and all ventral; *aa* approximately equals or, perhaps, is slightly (distinctly in one specimen) larger than *bc*, while *dd* is considerably more than half of the circumference—not much less than two-thirds.

The clitellum extends over segments xiii–xxi (=9), is saddle-shaped throughout, and not as thick on segment xiii as in the rest of its extent; in the specimen from Maungmagaun it includes segment xxii dorsally.

The prostatic pores are on xvii and xix, with the seminal grooves in the line of seta *ab*. The posterior pores appear to be very slightly further apart than the anterior pair: the grooves are slightly irregular in their course, and are bent a little outwards at both their anterior and posterior ends, to terminate in the pores (text-fig. 19). The grooves are enclosed by swollen, rather whiter

Text-figure 19.



Prostatic pores and seminal grooves, with the walls surrounding them.
of *Dechoqaster sinuosus* sp. n.

walls, which also surround the prostatic pores at each end of the grooves, and consequently bend out at their extremities. The male pores (openings of the vasa deferentia) were not seen.

The female pores are on segment xiv just in front of the setal zone, either almost directly in front of seta *a* or slightly external to this, between the lines of *a* and *b*.

The spermathecal apertures were seen in one specimen in furrow 8/9 slightly internal to *a*; none were to be discerned in 7/8 (though there are two pairs of spermatheca).

In furrow 8/9 there is a medianly situated transversely oval or eye-shaped swelling or cushion, not extending as far as the line of seta *a* on each side; in one specimen (Lashio) there is also a similar cushion in furrow 9/10; in another (Maungmagaun) the marking in 8/9 is very slight and would ordinarily have gone unnoticed, and there is a similar marking on segment x.

Internal Anatomy.

Septum 5/6 is perhaps slightly thickened, and 8/9–12/13 are all somewhat strengthened, 13/14 slightly so, while all those behind this level are very thin.

There are two gizzards, in segments vi and vii. Calciferous glands are present in xiv, xv, and xvi (or possibly xv, xvi, and xvii, if one can reckon the segments by the successive dilatations of the dorsal vessel; but in this case septum 14/15 must have been very thin and have been destroyed).

The last hearts are in xii.

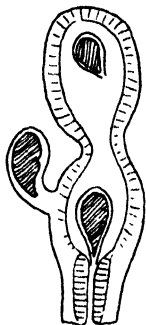
The nephridia are four, or sometimes five, on each side in each segment.

Testes and funnels were not seen. Small racemose seminal vesicles are present in segments xi and xii, but none were present in x. The prostates are two pairs, in xvii and xix, small tubular structures situated by the side of the intestine.

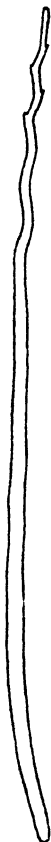
Ovaries were seen in segment xiii.

The spermathecae are two pairs (text-fig. 20). The ampulla is ovoid, and

Text-figure 20.

Spermatheca of *Dichogaster sinuosus*, sp. n.

Text-figure 21.

First kind of penial seta of *Dichogaster sinuosus*, sp. n. \times ca. 250.

constricted from the duct ; the latter is one-third as long again, and fully as wide, as the ampulla—wider at the middle of its length than at the ends. The diverticulum is single, and consists of an ovoid seminal chamber attached

by a short stalk to the duct rather above its middle; the diverticulum is directed upwards. One of the two spermathecæ which I mounted contains a pear-shaped spermatophore (?) in the ampulla and another in the duct; the other contains a similar structure in the duct only.

The penial setæ are of two kinds, one of each kind in each bundle. (i.) The first kind (text-fig. 21) is 0.43 mm. long, 6μ thick at the middle of its length, and 7μ near its base: the shaft is almost straight, very slightly bowed; the distal third is wavy, showing four or five undulations, the terminal 25μ being

Text-figure 22.



Second kind of penial seta of *Dichogaster sinuosus*, sp. n.

a, whole seta. \times ca. 250; b, distal end, \times 660.

straight; the shaft tapers gently, and ends bluntly in a rounded (but not swollen) point; the ornamentation consists of a few (about four) small scale-like projections on the distalmost undulations. (ii.) The second kind (text-fig. 22) is 0.4 mm. long but only 3μ thick at its middle and 4μ near its base, being thus notably thinner than the first kind; the shaft is nearly straight, with a very slight double curve (perhaps accidental); it is also sinuous, presenting three very faint undulations in its distal sixth; the tip, however, is straight beyond the undulations, thin, rounded at the end, and very slightly knobbed; the

ornamentation, which can only be faintly discerned even with the oil-immersion lens, consists of three minute projections on the most prominent parts of the distal undulations, as shown in the figure.

Subfamily *OCTOCHLETINÆ*.

Genus *EUDICHOGASTER* Mich.

EUDICHOGASTER CHITTAGONGENSIS Steph. (Text-figs. 23 & 24.)

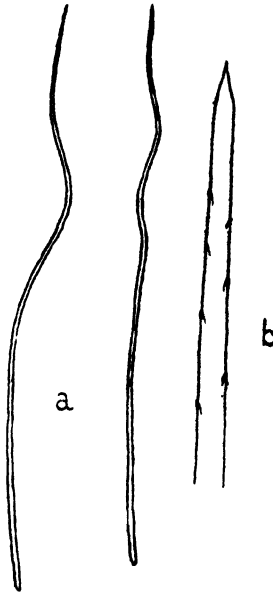
Rangoon. Prof. G. E. Gates. Six specimens.

Pantha. Upper Chindwin Dist., Burma. Prof. G. E. Gates. Six specimens.

I may supplement my previous description (Stephenson, '17) as follows :—

The first dorsal pore is, in the specimen more minutely examined, in furrow 12/13 (anterior border of the clitellum). The clitellum comprises all segment xiii and half or nearly all of xvii ($\approx 4\frac{1}{2}$ to nearly 5) ; it is wanting, however, ventrally on xvii, where the male field comes in. The prostatic pores are in

Text-figure 23.



Penial setæ of *Eudichogaster chittagongensis* Steph.

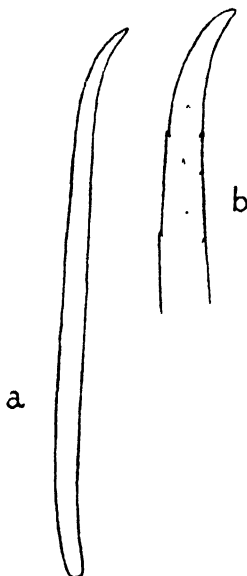
a, whole setæ, showing different curves, $\times 140$; *b*, distal end, $\times 1400$.

or immediately internal to the line of setæ *b*, on very slight papillæ ; female pores on xiv just internal to and in front of setæ *a* ; spermathecal pores on segment viii internal to setæ *a*, on small indefinite papillæ which also bear setæ *ab*.

I could not detect the testis sacs, or testis sacs conjoined with seminal vesicles, meeting above the alimentary canal, which I described in my former paper ; there was a mass of iridescent spermatozoa on both sides of segment x, but these masses were ventro-lateral in the segment and were far from meeting

dorsally. I saw no seminal vesicles. The prostates consist each of a convoluted tube, of two and a half short loops closely pressed together, in one plane; the duct is narrow and quite straight, nearly as long as the glandular part (in its natural condition, *i. e.*, not straightened out). The penial setæ, 0.54 mm. in length and $3\ \mu$ or a little over in diameter, are filiform (text-fig. 23), with an irregularly sinuous outline: the extreme tip is pointed, and the distal portion of the shaft shows slight irregularities of outline, which project only very slightly and can hardly be called teeth.

Text-figure 24.



Copulatory setæ of *Eudichogaster chittagongensis* Steph
a, whole seta, $\times 300$; *b*, distal end, $\times 750$.

The copulatory setæ, *a* of segment viii (text-fig. 24), not previously described, are 0.25 mm. long and $10\ \mu$ thick at the middle of their length; the shaft is almost straight, only very slightly bowed; the distal end is rather more curved and bluntly pointed. The ornamentation consists of a few extremely fine punctate pittings or scars scattered over the distal portion, and scarcely well visible even with the oil-immersion lens, which appear at the margins as extremely small incisions.

Subfamily OCNERODRILINÆ.

Genus GORDIODRILUS Bedd.

GORDIODRILUS UNICUS, sp. n. (Text-fig. 25.)

Bhamo, Burma. Prof. G. E. Gates. A single specimen, mature.

It is impossible to give a very full description of the dissection of a worm represented by a single specimen with a maximum diameter of one millimetre and I fear the following account reads like a mere synopsis or abstract.

External Characters.

Length 35 mm. ; maximum diameter 1 mm. A light flesh-colour. Segments about 85, but the furrows in the present specimen are almost obliterated.

Prostomium zygodobous.

Dorsal pores absent.

The setæ are paired : $aa=bc$, dd =half the circumference. .

The clitellum extends over segments $\frac{1}{2}$ xiii— $\frac{1}{2}$ xx ($=7$), but none of segment xx is included ventrally ; it is ring-shaped, smooth, and brownish in colour.

The anterior prostatic pores appear as whitish dots in the position of the ventral setæ of segment xvii ; the seminal grooves do not reach the anterior prostatic pores, but extend from segment xviii to segment xix—i. e., from the openings of the vasa deferentia to those of the posterior pair of prostates. The grooves and pores lie in the line of setæ *ab*, and the grooves are straight and surrounded by whitish walls : a square white male area may be described of which the grooves with their outer walls form the lateral boundaries.

The female pores were not seen.

The spermathecal pores are visible as small eye-like markings in grooves 7/8 and 8/9, in line with seta *b*.

Internal Anatomy.

Septa 6/7, 7/8, and 8/9 are considerably, 9/10, 10/11, and 11/12 slightly thickened, the rest thin.

There is no gizzard. The pharyngeal glands constitute definite lobular masses in segments v, vi, and vii. The single calciferous gland (œsophageal sac),

Text-figure 25.



Spermatheca of *Gordiodrilus unicus*, sp. n.

in segment ix, is a large ovoid sac, attached ventrally in the hinder part of the segment, extending forwards and bulging out at the sides, so that at first I thought there were two sacs. The intestine begins in segment xiii.

The last hearts are in segment xi.

The testes and funnels are free in segments x and xi (testes not identified). Seminal vesicles, rather small and only slightly lobed, are present in xii.

The tubular prostates are three in number on the right side (xvii, xviii, and xix) and two on the left (xvii and xix) ; they are rather long, much twisted, and may stray across the middle line into the opposite side of the body. The duct is the short ectal portion of the tube, which (in the posterior pair, but hardly in the other) is slightly narrower and slightly shiny. The vasa deferentia end in segment xviii.

Ovaries and funnels are of relatively large size in segment xiii.

The spermathecae (text-fig 25) are two pairs, in segments vii and viii; the ampulla is subspherical or broadly ovoid, and marked off from the duct; the latter is spindle-shaped, half as long again, and at its widest part three-fourths as wide, as the ampulla. There is a pair of small incipient diverticula, minute sessile knobs, at the middle of the length of the duct.

Family GLOSSOSCOLECIDÆ.

Subfamily GLOSSOSCOLECTINÆ.

Genus RHINODRILUS E. Perr.

RHINODRILUS CURTUS, sp. n. (Text-figs. 26 & 27.)

Summit of Mt. Tucouché (just over 3000 ft.), Trinidad. 4. v. 29. W. Cook. A single specimen, along with a specimen of *Pontoscolex coretherurus*.

External Characters.

The specimen showed a regenerating posterior end, the newly formed portion being 2.5 mm. long and 2 mm. broad at its base (just in front of this the worm is 6.5 mm. wide).

Length 110 mm.; maximum diameter 7.75 mm. (colour dark reddish brown. Segments 128 (*plus* the regenerated portion); no secondary annulation.

Prostomium absent: what looks like a slight eversion of the buccal mucous membrane represents segments i and ii, though it is only about two-fifths of a millimetre in length, and less than half as long as the next segment. The mouth is a transverse slit and the angles of the mouth are continued backwards to the anterior border of the next segment (*i.e.*, segment iii), these continuations representing the lateral grooves described in other species of the genus.

There are no dorsal pores.

The setae are closely paired, the lateral setae especially closely; all the setae are small, the lateral smaller than the ventral: the ventral setae are invisible in front of segment xi (except on segment vii, where they are just visible near furrow 7/8—genital setae), and very inconspicuous over the whole region in front of the genital field on xix; the lateral are invisible even for several segments behind the genital area. The ventral couples are rather close together on the ventral surface of the body, the lateral are in line with the nephridiopores, in the lateral line; $aa=4$ $ab=\frac{1}{3}$ bc , $cd=\frac{1}{3}-\frac{1}{4}$ ab , dd =half the circumference.

The clitellum is wanting.

On segment xxi is a mid-ventral depression which takes up the whole length of the segment and which is limited on each side by a sharply-cut longitudinal groove which traverses the segment from front to back a little outside the line of setae *b*; the sides of the depression slope inwards. Segments xx and xxii are a little swollen ventrally, especially at the sites of the ventral setal couples; but these setae (or their pits) are to be made out only with difficulty in xx, and not at all in xxii. In the depression on xxi are three minute pits on each side, of which the two outer on each side appear to be the pits of the ventral couple and the innermost, not far from the middle line, may be the male pore.

The female and spermathecal pores are not visible; but from the dissection the spermathecal ducts pierce the body-wall about one-third of the distance from the nerve-cord to the nephridiopores (which are in the lateral line), in furrows 6/7 and 7/8.

Internal Anatomy.

The numbering of the segments is somewhat confusing ; septa 6/7 and 7/8 are somewhat thickened, and so, indeed, are all the anterior septa as far back as 17/18. There is no septum attached in the position of furrow 8/9, which appears to be due, not to the absence of a septum, but to the shifting forwards of those in front.

The gizzard, in segment vi, is large and firm, and has the form of an obliquely-placed ring, the upper edge being also the anterior: indeed, the ring lies almost flat, the œsophagus coming out of its upper surface. There are no intestinal diverticula in xxvi or any neighbouring segment.

Calciferous glands are present in segments vii, viii, and ix, flattish and oval in shape, with the long axis transverse, lying dorsally in the segment, the narrow short stalk arising dorsally from the œsophagus. Microscopically they are paniced sacs; near the base of the gland the cavities are few, large, and rather irregular, and they become progressively more numerous, and also smaller, on proceeding from the base towards the free extremity of the gland; those in the centre of the gland are more regularly circular in transverse section, those at the periphery much larger and less regular; near the free extremity, however, the peripheral spaces also become smaller and more regularly circular in section. Near the base the diameter of the chambers is 80–200 μ ; at the middle of the gland it is still the same at the periphery, but only 20–50 μ in the centre, while towards the tip of the gland the chambers are only 12–20 μ in diameter in transverse section. The internal partition-walls between the tubular chambers contain a blood-space, which is continuous throughout at least a large part of the gland.

In segments x and xi the œsophagus is swollen and vascular, but there are no definite calciferous glands.

The last hearts are in segment xi; but smaller transverse vessels are present in xii, running over the seminal vesicles.

The nephridia are characterized by possessing a large vesicle with a considerable elongated dorsally extending cæcum.

The testes and funnels, in x and xi, are contained in testis sacs, which also, beside a quantity of iridescent coagulum, include the hearts, and, in xi, the seminal vesicles. These latter organs, in xi and xii, are small ovoid or rounded sacs, not lobed, and situated near the middle line.

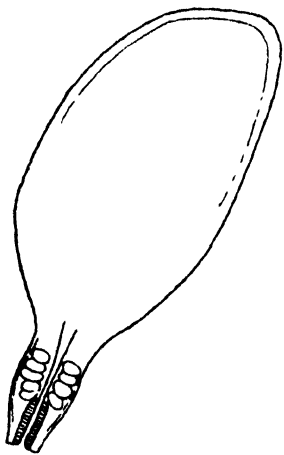
I could not distinguish any trace of ovaries, and saw no ovisacs.

In segment xxi are a pair of compact, massive prostates, brownish in colour, sessile on the body-wall, without visible ducts. In the segment in front, and in the three succeeding segments behind, situated in the ventral part of the segment and near the middle line, are a series of paired glands, irregularly bilobed, yellow in colour, and with lobular granular surface; these are setal glands, one lobe being in front of and the other behind the setal sac and muscles.

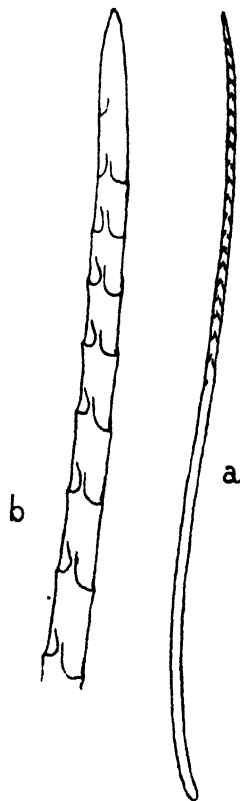
The spermathecae are two pairs, of unequal size, the posterior being the larger. The ampulla is shield-shaped (in the anterior) or ovoid (in the posterior), and directed backwards: the duct is fairly well marked off from the ampulla, and is short (in the posterior—one-fourth the length of the ampulla) or equal to the ampulla in length (in the anterior). There is no diverticulum, but the duct is slightly swollen (*i.e.*, spindle-shaped), and shining spermatozoa are seen in it through the wall; mounted in balsam (text-fig. 26) the spermatozoa are seen to be contained in small sperm-chambers in the substance of the wall, the chambers being massed in two groups, of 4–6 in each, one group on each side of the duct.

Near each spermatheca, just behind and very slightly to the outer side of the

Text-figure 26.

Spermatheca of *Rhinodrilus curtus*, sp. n.

Text-figure 27.

Copulatory setae of *Rhinodrilus curtus*, sp. n.a, whole seta, $\times 50$; b, distal end, $\times 225$.

entry of the duct into the body-wall, and correspondingly also in the segment in front of the anterior spermathecae, is an irregularly lobed transparent sac, the sac of the copulatory seta. The setae from these sacs (which do not seem ordinarily to project on the surface—cf. the account of the external characters) are 2 mm. long (text-fig. 27) and $28\ \mu$ in thickness at the middle of their length; they have a gentle double curve, become thinner gradually towards the free end, and are bluntly pointed; the distal half shows four longitudinal series of scar-like depressions, each deeper in its proximal portion and with a more sharply defined proximal margin; in each longitudinal series are about 20 scars. Similar setae are present in the region of the male pores; here they are rather shorter (1.45 mm.), and present 14–16 scars in each longitudinal series.

Remarks.

The species to which the present form has most likeness are *R. sieversi*, *R. appuni*, and *R. romani*. As compared with the first of these, the present worm is larger, but the setae are smaller, and more closely paired in the middle and hinder regions; the genital setae of the clitellar region are, in *R. sieversi*, of two forms, and those behind the male pore are much smaller than in the present form, while specially modified setae appear to be absent from the spermathecal region; the thickened septa and the disposition of the calciferous glands also differ in the two species. In *R. appuni* *aa* is about 12 *ab* (here is equal to 4 *ab*), and in general is not much smaller than *bc* (here it is only one-third of *bc*), while the spermathecal pores are in line with the nephridiopores (here they are much nearer the middle line). In *R. romani* also the setal ratios are different, the septa are all thin, and the spermathecal pores are not far below the nephridiopores.

The worm was obtained, along with those immediately to be noticed, from the top of Mt. Tucouché in Trinidad; of the locality the finder records that the summit of the mountain (just over 3000 ft.) is always moist, and the rain-forest extends up to the top, except for a bare space at the extreme summit. "The worms occur in the soil all over the last 200 ft. level just along the summit. The soil is always soft and damp, and their large mounds of castings are seen all over the path to the top. If one walks over a burrow, there is a distinct squeelching and bubbling noise, which is due to the worm suddenly retreating into the bottom of its burrow. This occurs almost every five or six steps one takes. These worms can be collected all the year round. There are none to be found on the lower reaches of the mountain, and the only other place I remember seeing them was at the top of Mt. Aripo, which is a little higher than Tucouché, but differs in that the rainfall forest extends all over the top in a thick covering, so that no view can be obtained."

Genus PONTOSCOLEX Schmarda.

PONTOSCOLEX CORETHRURUS (Fr. Müll.).

Same locality and finder as the last. Two specimens.

One of the specimens is an ordinary example of the common *Pontoscolex corethrurus*. The other, though it wants the anterior end, and apparently the hinder end also, is nevertheless 320 mm. long, and of very irregular thickness, 6–9 mm.; it is narrowly constricted in several places towards what is pretty certainly the hinder end. Throughout the specimen the setae are irregularly arranged in quincunx fashion, and towards what I take to be the hinder end

they are large—much larger and more prominent than in front. If this specimen is *Pontoscolex corethrurus*, it must be a giant among its fellows.

PONTOSCOLEX HINGSTONI, sp. n. (Text-figs. 28 & 29.)

Moraballi Creek, Essequibo River, British Guiana. 14.ix.29. Major R. G. Hingston. Seven specimens, two sexually mature, since the non-sexual specimens might possibly not belong to the same species, for the most part only the two sexual specimens were examined.

External Characters.

Length 83-90 mm., diameter in general about 3 mm., at the clitellum 4.5-5 mm., and tapering behind to a little over 2 mm. Pale, unpigmented. Segments of the longest specimen 143; secondary annulation in the hinder part of the body, three or four annulations per segment.

Prostomium proepilobous (?); segment i rudimentary or absent, segment ii marked by numerous radial grooves round the mouth. Anus vertical. The nephridiopores are in line with the lateral setæ.

On segment ii there are no lateral setæ, and in one of the two specimens one of the ventral bundles has only a single seta. The lateral couples are closely paired throughout the whole body except the hinder fourth or fifth, where the two setæ of a couple begin to diverge and are soon widely separated. In the anterior part of the body the lateral setæ are black and conspicuous, but towards the hinder end they become much more difficult to see.

The ventral setæ are closely paired at first, but begin to diverge almost immediately—in segment v; they are wider apart in vi and vii, and in viii $ab=aa=1\frac{1}{2}-2\ bc=i.e.,\ b$ is much nearer to c than to its proper associate a ; behind viii the interval ab diminishes again, and a few segments further back $ab=\frac{1}{2}\ aa=\frac{1}{2}\ bc$. In vii and viii the ventral setæ are large and conspicuous, and situated on indefinite whitish papillæ; this is also in some degree the case in a few segments in front of and behind those just named. In the second sexual specimen the ventral setæ of vii, viii, and ix are equally wide apart, and those of vii are the most conspicuous.

In the region of the genital ridges (xx-xxiii) the ventral setæ are again enlarged, conspicuous, and seated on circular papillæ, which are, however, smaller, though better defined than the papillæ of segments vii-viii and neighbouring segments; here ab is rather less than aa and is equal to two-thirds of bc . Behind the ridges, and in the middle region of the body, ab again $=\frac{1}{2}\ aa=\frac{1}{2}\ bc$, or nearly so; but towards the hinder end, when the lateral couple have diverged, $ab=\frac{1}{2}-\frac{2}{3}\ aa=\frac{2}{3}-\frac{3}{4}\ bc=cd$. Throughout the greater part of the body dd =half the circumference or a little less; in the hinder region dd is about one-third of the circumference. The setal arrangement is never the quincunx-formation; and in both these sexual specimens the irregularities in the lines of the setæ b and d are very slight.

Turning to the five non-sexual specimens (which are not certainly of the same species), in two, which are incomplete posteriorly, the setal relations are as described above; in a third, which is apparently complete, the line of setæ d is slightly irregular towards the hinder end. Of the remaining two specimens each has a long regenerated portion posteriorly; in one this is one-third the length of the worm, in the other more than one-third. In one of these two the lines abc are regular throughout the original portion of the worm, but d is irregular, within not very wide limits, from the point where cd begin to diverge—in this specimen one-third of the length of the worm from the anterior end; in the regenerated part of the worm the lines a and c are regular to the hinder end, b is irregular within fairly narrow limits, while d is widely

irregular, so that dd may be less than cd , and the interval cd is not usually the same on the two sides of the same segment; the arrangement is never in quincunxes. In the remaining specimen the lines a and c are regular throughout, while b is irregular within narrow limits in the posterior half, and d irregular within fairly wide limits throughout more than the posterior half of the worm; towards the hinder end cd may be equal to dd ; the arrangement is never in quincunxes.

In both the regenerated worms the setæ increase in size towards the hinder end.

Text-figure 28.



Seta of spermathecal region of *Pontoscolex hingstoni*, sp. n. $\times 165$.

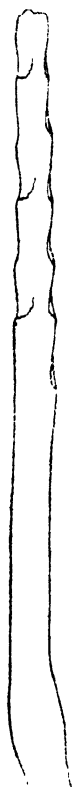
The ordinary setæ are 0.3 mm. long, with the usual sigmoid curve; the nodulus is distal (proximal : distal :: 5 : 3 or almost 2 : 1); the ornamentation consists of a small number of delicate sculpturings, transverse or slightly concave towards the tip, near the distal end.

A large number of setæ of the spermathecal and clitellar regions were obtained, but all, without exception, were found on examination to be broken. The spermathecal setæ (text-fig. 28) must have been more than 0.68 mm. long; the thickness of the shaft just below where the ornamentation stops is 32μ ;

the shaft is straight (as far as can be seen), except towards its proximal end, and there is a slight nodule 0.29 mm. from the proximal end. The ornamentation consists of a number of very conspicuous scars or semicircular depressions, in shape somewhat as if they had been made by pressing the finger-tip onto a plastic substance; each has a sharp margin, the concavity being towards the tip; the edges of the depressions are faintly jagged.

The clitellar setæ (text-fig. 29) (from the region of the genital ridges) are of the same length as those just described, but appear to be rather narrower (22–24 μ below where the markings stop): there is a faint indication of a nodule

Text-figure 29.



Seta of clitellar region of *Pontoscolex hingstoni*, sp. n. $\times 195$.

0.26–0.30 mm. from the proximal end; the sculpturings are not quite so close together as in the spermathecal setæ. In both groups the sculpturings appear at first to be more numerous than they are represented in the figures, but by focussing it can be recognized that a number are on the lower side of the shaft. All these setæ were broken at much the same level of the shaft.

The clitellum is rather indefinite, including xvi–xxiv (=9). The genital ridges are situated on xx–xxiii, midway between the lines of setæ *b* and *c*, and form the lateral boundaries of a rather rectangular ventral shield on these segments—a thickened area with the conspicuous ventral setæ on papillæ, as described above. The genital apertures were not seen.

Internal Anatomy.

An extremely tenuous membrane may represent septum 5/6, but the first definite septum is 6/7, which is moderately strengthened and pouched backwards to an extreme degree, so that the gizzard, which is in front of it, is at a level behind the spermathecae; 7/8 and 8/9 are also somewhat strengthened and much prolonged backwards, the hinder of those two septa being attached at a more posterior level (in one specimen at least) on the right side than on the left, not far from the position of furrow 9/10; the next septum, also moderately thickened, is attached at groove 10/11. Septum 9/10 thus appears to be absent. Behind 10/11 distinct septa seem to be absent for some distance dorsally, where they are represented by a fine spongy connective tissue, but a number of septa can be distinguished from 12/13 onwards at the sides of the alimentary canal, and segmentation is here indicated also by the nephridia. The relations of the organs are somewhat obscured by the extreme pouching backwards of the anterior septa.

The gizzard—firm, rounded, and of fair size—is in front of septum 6/7. The calciferous glands, in segments vii, viii, and ix, of moderate size, are ovoid sacs, attached by narrow stalks dorsally to the œsophagus at the posterior limit of their segments; the stalks, gradually widening, extend first forwards and rather downwards and then the sac bends upwards and appears dorsally, reaching nearly to the middle line.

In a series of transverse sections taken through sacs and œsophagus, and beginning at the hinder limit of the segment, the stalks of the sacs are seen to communicate with the œsophagus, one on each side of the mid-dorsal line, by an epithelium-lined canal; the sacs extend forwards lateral to the œsophagus, and in section become as large as, and in places much larger than, the section of the œsophagus. The chambers are at first few, and increase in number and diminish in size as the sections pass forwards; half-way along the series at a rough computation 150 chambers are seen in the section of each gland, and the average diameter of the chambers in the anterior portion of the gland may be 40–60 μ .

There are two pairs of large hearts behind septum 10/11—those, perhaps, of segments xi and xii. The vascular commissures of segments xvi, xvii, and xviii are conspicuous, especially the last; they increase in size backwards.

The nephridia possess the muscular “sphincters” characteristic of certain genera—well defined spherical or subspherical masses of muscular tissue situated at the wide angle of the large, triangular bladder where this joins the body-wall. Examined roughly, in glycerine, the muscular fibres did not seem to encircle the neck of the bladder in the manner of a sphincter, but appeared to be arranged vertically in the bulbous mass, parallel to the canal.

There is a pair of combined testis sacs and seminal vesicles; the anterior, more swollen portion of each contains an iridescent mass of spermatozoa, and is situated in the region behind septum 12/13; it represents the testis sac. The sacs of the two sides are joined ventrally beneath the œsophagus by a median sac, also full of iridescent coagulum, which in antero-posterior extent takes up segments xiv–xv.

The anterior swollen portion of the sac (testis sac) extends to about the level of xvi or xvii; the sac then narrows and, as the seminal vesicle, extends back on each side to xxxii; in this part of its extent it is irregularly thicker and thinner, and somewhat nodular. In the other specimen one vesicle extends back to xxvii, the other to xxxiii and then bends forwards again for a few segments.

The vas deferens, at first much twisted, leaves the testis sac at its anterior end and enters the body-wall in segment xiii; it can, however, be followed

back without great difficulty. It follows a line external to that of setæ *b*, but nearer *b* than *c*, and ends by joining a longitudinally elongated soft, white, glandular mass on the body-wall beneath the peritoneum. This mass can be distinguished as composed of three portions, incompletely separated from each other, over the situation of furrows 20/21, 21/22, and 22/23. By scraping away the glandular mass the vas deferens is seen to end on the anterior part of segment xxi, apparently just behind the furrow, outside the line of *b* but nearer *b* than *c*; the duct becomes somewhat thicker before it pierces the body-wall.

The ovaries were not identified, but the oviducts lead outwards and forwards from the small funnels and enter the body-wall in segment xiv between the lines of setæ *a* and *b*. Thus both male and female gonads are shifted some distance backwards from their normal positions.

The spermathecae are three pairs; the ampullæ are flattened and circular or oval in shape, with, in most cases long, thin, straight ducts, the length of the ducts being due to the backward elongation of the segments in which they lie, owing to the pouching of the septa already referred to. They are situated in segments vii, viii, and ix, and the ducts pass forwards to end in furrows 7/8, 8/9, and 9/10, in a line with the lateral setæ; the ducts of the second pair are longer than those of the first, and those of the third pair are very long and thin, the ampulla, though in segment ix according to the septa, being on a level with segment xii as seen externally.

Family LUMBRICIDÆ.

Genus DENDROBÆNA Eisen.

DENDROBÆNA OCTAEDRUS (Sav.).

Kungs-suk (near Godthaab), W. Greenland, alt. 30 ft., in soil and under stones and buried in the carpet of moss. Major R. G. Hingston. Two specimens, mature.

Genus ALLOLOBOPHORA Eisen, em. Rosa.

ALLOLOBOPHORA CALIGINOSA (TYPICA) (Sav.).

Toulouse. Nov. 1929. Dr. F. G. Holdaway. Nine specimens, sexually mature.

ALLOLOBOPHORA SAVIGNYI (Guerne & Horst) var. MINOR, var. n.

Toulouse. Nov. 1929. Dr. F. G. Holdaway. A single specimen, mature.

External Characters.

Length 154 mm.; maximum diameter 10 mm., behind clitellum 8.5 mm. Colour slaty grey dorsally, paler ventrally. Segments 200; a number of segments in the anterior part of the body, in front of the male pores, bi- or tri-annulate.

Prostomium epilobous $\frac{1}{2}$, cut off behind by a transverse groove which extends some little distance laterally beyond the limits of the tongue.

The first dorsal pore is in furrow 12/13, but I was doubtful whether there was one in the furrow next behind this or not.

The setæ are rather closely paired; *ab* is somewhat greater than *cd*; in at least the posterior third of the body $aa=2bc$, in the middle of the body *aa* is relatively rather less, while behind the clitellum $aa=1\frac{1}{2}bc$ and in front of the clitellum $1\frac{1}{4}bc$; *dd* is half the circumference, or in the anterior region perhaps rather less. The setæ of the anterior segments are not enlarged.

The clitellum is saddle-shaped and extends over segments xxxi-xliii (=13) ; intersegmental furrows are present and distinct, and setæ are visible ; there is a slight change of colour dorsally. The ridges of puberty are very well defined, extending over xxxiii-xxxviii ; the ventral setæ of segments xli and xlii, and of xliii on the right side, are situated on glandular swellings.

The male pores are slit-like, with swollen glandular anterior and posterior lips which take up the whole length of segment xv, the posterior lip obliterating furrow 15/16 where it abuts on it, and joining the glandular papilla on xvi (*v. inf.*). The position of the pores is just outside the line of setæ *b*, the inner end of the slit-like aperture very nearly reaching the line.

The female pores, on xiv, are a little outside the line of *b* ($ab=b♀$), and very slightly posterior to the level of the setæ.

The spermathecal pores are not visible ; from internal examination they are seen to be usually two on each side in each of furrows 13/14 and 14/15, in or about the line of *d*. Glandular papillæ surround the ventral setæ of segments xi, xii, xiii, xiv, xvi, and, on the left side, xvii ; the swellings round the setæ of xi and xii are very well marked. There are none round the ventral setæ of xxvi.

Internal Anatomy.

The retractor muscles of the pharynx are very numerous and strong.

Septum 4/5 is thin, 5/6 moderately strong, 6/7-9/10 all very thick, 10/11 moderately strengthened, the rest thin.

The gizzard takes up segments xvii-xx.

The last hearts, which are moniliform, are in segment xi.

Testes and funnels are free in segments x and xi, along with flocculent and iridescent coagulum. Seminal vesicles are present in segment ix as rather small lobed sacs, larger than those in x, but smaller than the two posterior pairs ; in segment x they are small, rounded, and slightly lobed ; in segments xi and xii the vesicles are large, meeting in the middle line, and very deeply cut up into rounded lobules.

In segment xiii the female funnels were seen, and in xiv are small ovisacs.

The spermathecae are situated in or about the line of setæ *d* in furrows 13/14 and 14/15 ; they are small, round, sessile sacs, two in number in each situation, except that on the right side in 13/14 there was only a single one, and that one of the two on the right side in 14/15 was divided into two rounded halves by a constriction.

Remarks.

Allolobophora savignyi is a remarkably large worm, attaining a length of 350 mm. and a diameter of 12 mm. Besides being much smaller, the present specimen differs in the extent of the clitellum (to xliii instead of xliv), the position of the tubercula pubertatis (xxxiii-xxxviii instead of xxxiv-xxxix) and of the first dorsal pore (12/13 instead of 10/11 or 9/10), and in possessing spermathecae in furrows 13/14 and 14/15 (instead of in 13/14, 14/15, and 15/16), as well as in one or two smaller points.

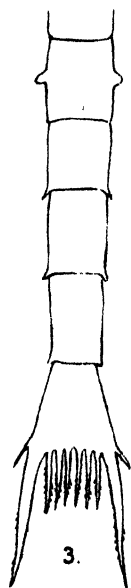
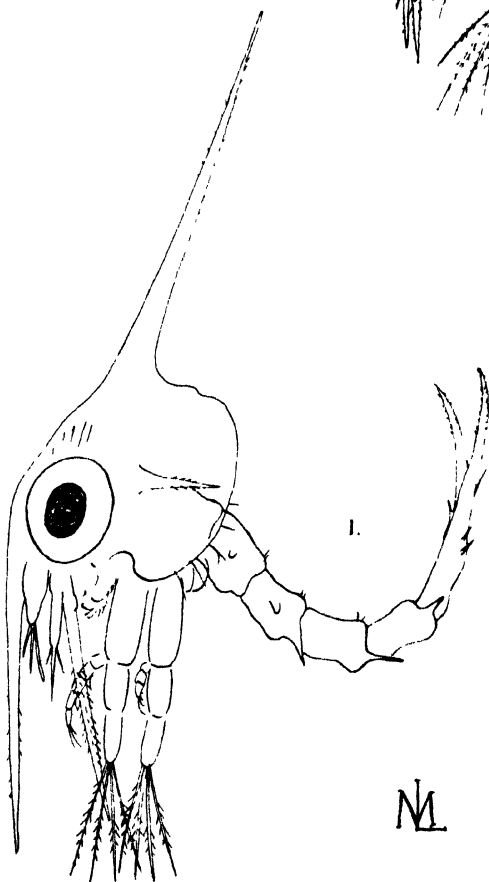
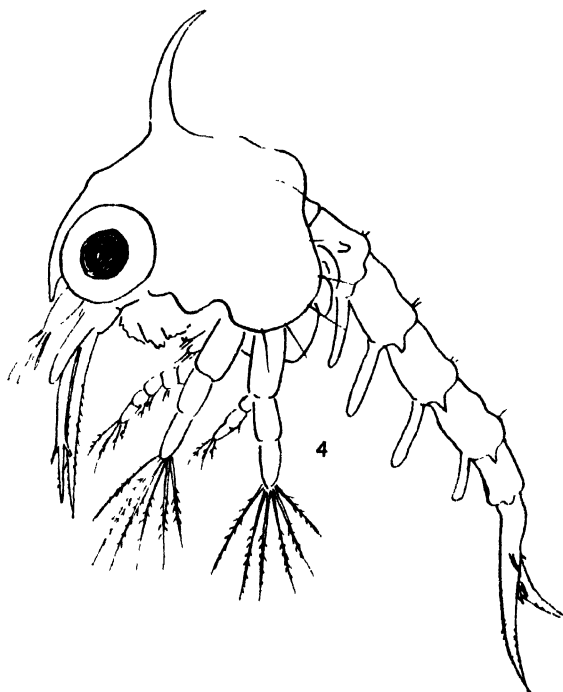
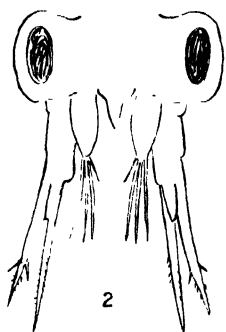
It is unfortunate that the present form is represented only by a single specimen ; it is possible that the position of the tubercula pubertatis and of the spermathecae may entitle it to rank as a separate species. Both this worm and *A. savignyi* are from the south-west of France, though there is more than 100 miles between the localities in which they were respectively found.

REFERENCES TO LITERATURE.

- '95. BEDDARD, F. E. A Monograph of the Order of Oligochaeta. Oxford.
- '21. DELPHY, J. Lombriciens limicoles thalassophiles. Paris.
- '79. EISEN, G. On the Oligochaeta collected during the Swedish Expeditions to the Arctic Regions in the years 1870, 1875, and 1876. K. svenska Vetensk.-Akad., Handl. n. s. xv. no. 7.
- '00. EISEN, G. Researches in the American Oligochaeta, with especial reference to those of the Pacific Coast and adjacent Islands. Proc. Calif. Acad. Sci. (3) ii.
- '99. FERRONIERE, G. Contribution à l'étude de la faune de la Loire-Inférieure. III. Bull. Soc. Sci. nat. Ouest Fr. ix.
- '29. GREGORY, J. W. Presidential Address to the Geological Society of London (abstract). Nature, cxix.
- '23. HEMPELMANN, F. Kausal-analytische Untersuchungen über das Auftreten vergrösserter Borsten und die Lage der Teilungszone bei *Pristina*. Arch. mikr. Anat. xvi.
- '30. IHERING, H. VON. Land-bridges across the Atlantic and Pacific Oceans during the Kainozoic Era (abstract). Nature, cxv.
- '99. MICHAELSEN, W. Terricolen von verschiedenen Gebieten der Erde. Mitt. naturh. Mus. Hamburg, xvi.
- '00. MICHAELSEN, W. Das Tierreich. Oligochaeta. Berlin.
- '03. MICHAELSEN, W. Oligochäten von Peradeniya auf Ceylon. Sitzber. böhm. Ges. Wiss. 1903.
- '05. MICHAELSEN, W. Zur Kenntnis der Naididen. Zoologica, Heft xlv.
- '09. MICHAELSEN, W. Oligochaeta, in Die Süsswasserfauna Deutschlands, xii. Jena.
- '10. MICHAELSEN, W. Oligochäten von verschiedenen Gebieten. Mitt. naturh. Mus. Hamburg, xvii.
- '13. MICHAELSEN, W. The Oligochaeta of Natal and Zululand. Ann. Natal Mus. 1913, ii.
- '26. MICHAELSEN, W. Schwarotzende Oligochäten nebst Erörterungen über verwandtschaftliche Beziehungen der Archioleochaeten. Mitt. zool. Mus. Hamburg, xii.
- '06. PIGUET, E. Observations sur les Naididées et revision systématique de quelques espèces de cette famille. Rev. suisse Zool. xiv.
- '09. PIGUET, E. Nouvelles observations sur les Naididées. Ibid. xvii.
- '13. PIGUET, E., in Piguët & Bretscher, Oligochètes, in Catalogue des Invertébrés de la Suisse, fasc. vii. Genève.
- '69. RATZEL, F. Beiträge zur anatomischen und systematischen Kenntnis der Oligochäten. Z. wiss. Zool. xvii.
- '15. SCHUSTER, R. W. Morphologische und biologische Studien an Naiden in Sachsen und Böhmen. Int. Rev. Hydrobiol. vii., Biol. suppl. Heft ii.
- '13. SOUTHERN, R. Clare Island Survey. Oligochaeta, Gephyrea, and Hirudinea. Proc. R. Irish Acad. xxi.
- '09. STEPHENSON, J. The Anatomy of some Aquatic Oligochaeta from the Punjab. Mem. Ind. Mus. i.
- '10. STEPHENSON, J. On some Aquatic Oligochaete Worms commensal in *Spongilla carteri*. Rec. Ind. Mus. v.
- '15. STEPHENSON, J. On a Rule of Proportion observed in the Setæ of certain Naididæ. Trans. Roy. Soc. Edinburgh, i.
- '16. STEPHENSON, J. On a Collection of Oligochaeta belonging to the Indian Museum. Rec. Ind. Mus. xii.
- '17. STEPHENSON, J. On a Collection of Oligochaeta from various parts of India and Further India. Rec. Ind. Mus. xiii.
- '18. STEPHENSON, J. Aquatic Oligochaeta of the Inle Lake. Rec. Ind. Mus. xiv.
- '20. STEPHENSON, J. On a Collection of Oligochaeta from the lesser-known parts of India and from Eastern Persia. Mem. Ind. Mus. vii.
- '23. STEPHENSON, J. Oligochaeta, in 'The Fauna of British India' series. London.
- '24. STEPHENSON, J. On some Indian Oligochaeta, with a Description of two new genera of Oeneroдрilinae. Rec. Ind. Mus. xxvi.
- '25. STEPHENSON, J. On some Oligochaeta mainly from Assam, South India, and the Andaman Islands. Rec. Ind. Mus. xxvii.

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- '25 *a*. STEPHENSON, J.—Oligochaeta from Various Regions, including those collected by the Mount Everest Expedition, 1921. Proc. Zool. Soc. London, 1925.
- '30. STEPHENSON, J.—The Oligochaeta. Oxford.
- '30 *a*. STEPHENSON, J. An Oligochaete Worm parasitic in Frogs of the Genus *Phrynomerus*. Ann Mag. Nat. Hist. (10), vi.
- '26. STILES, C. W. & HASSALL, A. Key Catalogue of the Worms reported for Man. Hygienic Lab. Bull. no. 142 (Treasury Dept., U.S. Public Health Service).
- '92. UDE, H. Würmer der Provinz Hannover. I. Enchytræidae. Jber. naturh. Ges. Hannover. 1892.
29. UDE, H. — Oligochaeta. in Die Tierwelt Deutschlands . . . hgbn. F. Dahl. Jena.
- '94. VEJDovsky, F.—Description du *Dero tonkinensis*, n. sp. Mem. Soc. zool. Fr. vii.



LARVAL STAGES OF THE BRACHYURA



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6 Further Notes on Larval Brachyura. By MARIE V. LEBOUR D.Sc.,
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[Received September 24, 1930: Read February 3, 1931.]

(Plates I. & II.*)

Since the publication of "The Larval Stages of the Plymouth Brachyura" (Lebour, 1928) certain interesting additions have been made to our knowledge of crab larvæ. *Pisa biaculeata* has been hatched from the egg and reared as far as the second zoea; *Bathynectes longipes* has again been hatched, and this time a coloured drawing made of the first zoea; *Gonoplax rhomboides* has been hatched from the egg, confirming the work done from the plankton specimens; and the first zoea of *Hyas araneus*, kindly hatched out from the egg by Mr. H. O. Bull at Cullercoats, Northumberland, has been examined and compared with the zoea of *Hyas coarctatus*, thus enabling us to distinguish the two larvæ, which, up to the present time, have been somewhat confused.

BATHYNECTES LONGIPES Risso. (See Lebour, 1928, p. 515, pl. iv. fig. 7.)
(Pl. I. fig. 1.)

Several females in berry have been seen during the last four years, in May and June. One lot hatched out on May 27th, 1929, and from one of these zoeæ the drawing in colour was made. The colour is purplish brown, the darkest part being concentrated in the mouth and thoracic regions, with large chromatophores on the abdominal segments and one in the front of the dorsal spine at about the middle of its length; light purplish brown all over the body, with a little pale yellow.

Eggs round, ca. 0.32 mm. in diameter when ready to hatch.

GONOPLAX RHOMBOIDES (L.). (See Lebour, 1928, p. 534, pl. ii. fig. 6; pl. xi. fig. 10; pl. xii. figs. 1-4.)

This crab has already been hatched out by Dr. E. Caroli (1926) at Naples in 1921 (as *G. angulata*), who describes the four zoeal stages and the megalopa which changed into a crab, but gives no figures. This work had not been seen when the first paper was written (Lebour, 1928), and thus Dr. Caroli was the first to hatch out and describe the larvæ of *Gonoplax* correctly. His description agrees very well with mine. *Gonoplax* in berry have been seen several times during the last three years, always in late spring or summer, from May to August. On one occasion, June 13th, 1930, four berried females were obtained from the Rame mud. The eggs measure ca. 0.48 mm. in diameter and are round. The colour is bright pink in early stages, turning browner when ready to hatch.

HYAS ARANEUS (L.). (See Lebour, 1928, p. 545.) (Pl. II. fig. 1.)

The zoeæ hatched from the eggs of *Hyas araneus*, from Cullercoats, Northumberland, agree in all essentials with those of *Hyas coarctatus*, but are slightly larger, the spines a little longer and not so prickly. In some specimens the spines were almost smooth, and in no case did they approach the roughness

* For explanation of the Plates, see p. 96.

of the Plymouth specimen of *Hyas coarctatus* nor those described by Stephenson (1912, 1916); neither are they nearly so prickly as the specimens of *Hyas araneus* described by Williamson (1911, 1914) from larvæ hatched by Mr. Waddington at Bournemouth and from plankton specimens taken in the neighbourhood of Aberdeen. This last is remarked by Stephenson (1916), who suggests that they may be *Hyas coarctatus*. Certainly they are more like that species than they are like the present specimen of *Hyas araneus*. These larvæ from Cullercoats establish the fact that the zoæ of both the British species of *Hyas* have the characters as given for the genus *Hyas* in my former paper (Lebour, 1928, p. 544). It is now possible to separate the two species, although they are much alike, *Hyas araneus* being slightly larger, with longer and less prickly spines.

Berried females are common in the Cullercoats neighbourhood. They have been recorded from the Plymouth district, but not seen for many years. Eggs from Cullercoats were obtained in March and April, and were hatched out by Mr. H. O. Bull in March.

Eggs round, or very nearly so, ca. 0.64 mm. in diameter when nearly ready to hatch (those of *Hyas coarctatus* ca. 0.56 mm.): orange, changing to brownish black.

First zoea from egg ca. 2.5 mm. long from the base of the rostrum to the tip of the telson (those of *H. coarctatus* ca. 1.8 mm., sometimes rather longer); from the tip of the dorsal spine to the tip of the rostral spine ca. 3.36 mm. (in *Hyas coarctatus* ca. 3 mm.): dorsal spine ca. 1.4 mm. long; rostral spine ca. 1 mm. long (in *Hyas coarctatus* dorsal spine ca. 1.2 mm., rostral ca. 0.88 mm.). antennules and antennæ much the same in the two species, also the form of the carapace and its lateral spines, appendages, and armature of the abdomen. Spines in *Hyas araneus* much less prickly, especially the dorsal spine, which may be nearly smooth.

PISA BIACULEATA (Montagu) = *Pisa gibbsi* Bell. (See Lebour, 1928, p. 544.) (Pl. I. fig. 2; Pl. II. figs. 2-5.)

Only one female in berry has been seen since July 1926, the eggs of that specimen measuring 0.72 mm. by 0.64 mm. The second crab was obtained from 2½ miles south of the Mewstone, on August 5th, 1930, the eggs fairly well developed and measuring 0.72 to 0.80 mm. by 0.64 to 0.66 mm. This crab was put in a plunger-jar and the eggs hatched out during the night of August 17th. Unfortunately they did not develop further than the second (last) zoea, but enough was seen to show that the larvæ agree well with Cano's description and figures of the larvæ of *Pisa*, which may be *P. biaculeata*, *P. armata*, or *P. corallina*, for he does not distinguish the species (Cano, 1893). As has been noted already (Lebour, 1928, p. 544), the figure of the zoea given by Gourret (1884) represents a *Pinnotheres* (probably *P. veterum*), although his description and the figures of the telson and antenna are truly those of *Pisa*. The explanation must be that the numbers on the plates were wrong, for he must most certainly have seen the true zoea of *Pisa* (in his case *Pisa corallina*).

The first zoea of *Pisa biaculeata* is brilliantly coloured, and measures ca. 2.8 mm. in length from the base of the rostrum to the end of the telson, and ca. 1.28 mm. from the tip of the dorsal spine to the tip of the very short rostrum. The main colouring is dark brown and yellow dashed with red; the dorsal spine is yellow from the base up to about half its length; there is yellow above the eye on the maxillipedes and along the abdomen and telson; red in the neighbourhood of the mouth-parts and ventral part of the thorax, and especially on the last abdominal segments and telson; orange-red on the spinous process

of the antenna and on the maxillipedes; dark brown on the mandibles, along the alimentary canal, especially in the thoracic region and on the abdominal segments, with small brown chromatophores on the antennæ and maxillipedes.

The first zoea is much more like that of *Inachus* and *Macropodia* than it is like *Hyas*, the only essential differences being the rudimentary rostrum, which in the *Inachinae* is absent. In the second zoea, however, the abdomen is divided into six segments plus the telson, whilst in the *Inachinae* there are only five and there is a small fifth pleopod, whilst there are only four in the *Inachinae*. In these two features it resembles *Hyas*. In all other essential features it agrees with the characters of the *Inachinae* as summarized in my former paper (Lebour, 1928, p. 545-6.)

The first zoea emerging from the pre-zoea has a short, curved, dorsal spine on the carapace and a very short rudimentary rostral spine reaching a very little way beyond the eyes, both spines smooth, lateral spines absent, antennæ with the exopodite nearly as long as the spinous process, the latter slightly prickly, flagellum well developed; lateral knobs on the second abdominal segment; lateral spines on the third, fourth, and fifth segments; telson with one lateral spine, the six internal setæ arranged almost in a straight line, with the hind margin of the telson hardly indented; horns of the telson with minute spicules.

Second zoea obtained from the first zoea and much like it, hardly any larger, but with a sixth abdominal segment cut off from the telson: no additional internal setæ at the hind margin of the telson. Cano's figure of the second zoea of *Pisa* has the antennule segmented, whilst the Plymouth specimens have no trace of segmentation, again showing advance in development in Mediterranean forms which has already been noted in *Maia* and others.

The megalopa has not been obtained at Plymouth. According to Cano it has a pointed rostrum, with an indication of two lateral spines and a very small dorsal spine near the hind end of the carapace. It is difficult, from the figure, to compare it with *Hyas* or the *Inachinae*, but on the whole it seems to resemble *Inachus* rather than *Hyas*. As in all spider-crabs, the two zoeæ are well developed, and even in the first stage the thoracic limbs and pleopods can be seen.

The following table shows the relationship of *Pisa* to *Inachus* and *Macropodia* on the one hand and *Hyas* on the other:—

| <i>Inachus</i> and <i>Macropodia</i> . | <i>Pisa</i> . | <i>Hyas</i> . |
|--|--|---|
| Smooth dorsal spine, no laterals, no rostral spine. | Smooth dorsal spine, no laterals, rudimentary rostral spine. | Spiny dorsal, lateral and rostral spines; all present and well developed. |
| Antenna with exopodite as long as, or nearly as long as, the spinous process; flagellum well developed in both zoeæ. | Antenna with exopodite nearly as long as the spinous process; flagellum well developed in both zoeæ. | Antenna with exopodite less than half the length of the spinous process; flagellum rudimentary in first zoeæ. |
| Telson with one lateral spine; no extra internal setæ in second zoea. | Telson with one lateral spine; no extra internal setæ in second zoea. | Telson with two lateral spines in both zoeæ; a pair of extra internal setæ in second zoea. |
| Abdomen with five segments (plus telson) in second zoea; only four pairs of pleopods. | Abdomen with six segments (plus telson) in second zoea; fifth pair of pleopods rudimentary. | Abdomen with six segments (plus telson) in second zoea; five pairs of pleopods. |
| Lateral knobs on second abdominal segment. | Lateral knobs on second abdominal segment. | Lateral knobs on second and third abdominal segments. |

Thus *Pisa* is more like *Inachus* and *Macropodia*, differing in having a sixth abdominal segment in the second zoea and in having a rudimentary rostrum.

From the larval characters it seems that it would be advisable to keep the subfamily *Pisinæ* for *Pisa* together with certain foreign crabs, including *Lissa*, which, according to Cano, closely resembles *Pisa* in development, and to place *Hyas* in a new subfamily. This subfamily should come after the *Mainæ*, and the *Pisinæ* should be placed between this new subfamily and the *Inachinæ*. In this way *Hyas* would come nearest to the *Mainæ* in the family Maiidæ, *Pisa* having an intermediate position between *Hyas* and *Inachus*.

LITERATURE.

- CANO, G. 1893. Sviluppo e Morfologia degli Oxyrhynchi. Mitt. Zool. Stat. Neapel, Bd. x. Hft. 4, pp. 541-581.
- CAROLI, E. 1926. Sviluppo larvale della *Gonoplax angulata* (Pennant). Boll. Soc. Nat. Napoli, xxxviii. (ser. 2. xviii.), Anno xl. 1926, pp. 161-166.
- GOURET, P. 1884. Considérations sur la faune pélagique du Golfe de Marseille." Part I. Ann. Musée d'Hist. Nat. de Marseille. Zool. i., ii. pp. 1-175.
- LEBOUR, M. V. 1928. The Larval Stages of the Plymouth Brachyura. Proc. Zool. Soc. Lond. 1928 (July 18th), pp. 473-560.
- STEPHENSEN, K. 1912. Report on the Malacostraca collected by the 'Tjalfe' Expedition. Vid. Medd. f. d. Nat. Foren. Bd. lxiv. pp. 57-134.
- STEPHENSEN, K. 1916. Zoographical Investigations of certain Fjords in Southern Greenland. Medd. om Grønland, liii. pp. 231-378.
- WILLIAMSON, H. C. 1911. Report on Larval and Later Stages of Certain Decapod Crustaceans. Fisheries Scotland. Sci. Inv. 1909, 1 (Dec. 1910). pp. 1-20.
- WILLIAMSON, H. C. 1915. Decapoden. I. Teil (Larven). Nordisches Plankton. 18th Lief. vi. pp. 1-588.

EXPLANATION OF THE PLATES.

PLATE I. (coloured).

- Fig. 1. First zoea of *Bathynectes longipes*, 1.25 mm. long, hatched from egg, Plymouth.
2. First zoea of *Pisa biaculeata*, 2.6 mm. long, hatched from egg, Plymouth.

PLATE II.

- Fig. 1. First zoea of *Hyas araneus*, 2.5 mm. long, hatched from egg by Mr. H. O. Bull, Cullercoats, Northumberland.
2. Abdomen of first zoea of *Pisa biaculeata*.
3. Front of carapace of same, with antennules and antennæ.
4. Second zoea of *Pisa biaculeata*, 2.8 mm. long.
5. Sixth abdominal segment and telson of same.

7. The Middle Ear of the Horse (*Equus caballus*).

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(Text-figures 1-12.)

The notes collected in this paper are of the principal results obtained in the years 1929-1930 from a study of the comparative anatomy of the auditory organ, made under grant from the Government Grant Committee of the Royal Society of London, and concern the middle ear of the horse, with comparative references to that of the domestic sheep (*Ovis aries*).

The results constitute the first part of a general study of the middle and inner ear of the horse, the second part of which will be devoted especially to the labyrinth.

Nothing like a complete anatomical description has been attempted, as the literature on the subject is already extensive, and only mention is made of results which are either entirely new or are supplementary to those already recorded by others, but in cases where the results obtained are at variance with those already recorded the differences and references are pointed out.

The external ear has not been dealt with, as this has been exhaustively and admirably described by many authors on both comparative anatomy and special equine anatomy in the literature of several countries.

It may, however, be of interest to note that the structure of the integumentary lining of the external auditory meatus of the horse and that of the sheep show differences which are well marked, and, so far as I know, have not been hitherto recorded.

The papillæ of the derma of the external auditory meatus of the horse are small, numerous, and slender, while those of the sheep are comparatively few in number. These are much larger than in the horse, and, instead of being slender and pointed, are broadly rounded and wave-like, and do not, so far as I have seen, show bifurcation. The ceruminous glands of the horse are rather small, comparatively few in number, globular in shape, and well isolated.

Those of the sheep are much larger, often ovoid in shape, and so numerous that in many places they occur so close together as to give the appearance of a chain of glands.

THE TYMPANIC MEMBRANE.

This consists of two parts, the tense membrane, or membrana propria, and the flaccid membrane of Shrapnell.

The membrana propria is inserted into the sulcus tympanicus of the annulus, which is raised well above the tympanic wall and supported by a number of radiating septa, which are continued into and form long, curved divisions within the bulla.

The annulus tympanicus has a mean length of 11 mm., and its diameter (from before to behind) is about 8.20 mm. It is incomplete at its upper part for a distance of 4 mm. transversely.

The limits of the annulus mark the limits of the membrana propria, and the attachment of the processus brevis of the malleus to the drum being lower than the limits of the annulus, a somewhat triangular space is left (Prussak's space), which is occupied by Shrapnell's membrane, or the flaccid membrane, the fibrous portion of which consists of straight, vertical fibres which merge into the integumentary lining of the external auditory meatus above and converge towards the attachment of the processus brevis of the malleus below.

The external auditory meatus opens freely against the external side of the drum for about two-thirds of the length of that membrane. At this point, below, it is met by a well-marked bony elevation of the outer tympanic wall, and from thence for the distance of the lower third of the drum, the wall and the tympanic membrane are only separated by a very narrow space.

In the formation of the lamina propria of the tympanic membrane an important share is taken by periosteal structures.

In the horse the periosteum of that portion of the external auditory meatus formed by the annulus tympanicus is undoubtedly continuous with the lamina propria.

At the superior part, where the annulus is incomplete, the periosteum of the meatus is continuous with that of the vault. In the human subject it was, I believe, Driaspul who first pointed out that the lamina propria of the drum is continuous with the periosteum of the annulus.

In the sheep the annulus tympanicus is raised further from the wall than it is in the horse, and consequently projects to a greater degree into the cavity of the tympanum. It is supported by prominent septa, but these septa do not extend far below into the bulla as they do in the horse, and they rapidly become mere traces. The mean measurements of the annulus in the sheep are 9 mm. as to length, and 7 mm. in width.

The thickness of the membrana tympani of the horse varies a little, even in perfectly normal conditions, between 0.1 mm. and 0.2 mm.

Ellenberger and Müller (5) give the thickness of the drum of the horse as 0.2 mm. I should rather place this as a maximum, as in thoroughbred horses and some of the lighter breeds this is probably not usually reached.

THE TYMPANIC CAVITY. (Text-fig. 1.)

In the horse this is of an irregularly curved form (from side to side), and is smaller at its upper than at its lower extremity. Its upper part, the vault or attic, inclines forwards and downwards, while its middle portion, the atrium, shows a sharp curvature of the anterior wall backwards into the cavity. Below this point the cavity inclines forwards, and from the lower margin of the annulus tympanicus enlarges into the hypotympanic space or bulla.

The mean total height of the cavity is 30 mm., of which the vault occupies 7 mm., the atrium 13 mm., and the hypotympanic space 10 mm.

The long or transverse diameter (antero-posterior) of the vault is 10 mm., and it is of ovoid form, showing on its inner wall a well-marked salient which corresponds roughly to the position of the articulation between the malleus and the incus.

In the horse the mean width of the atrium (from before to behind) is 6 mm., and the mean width of the hypotympanic space, in the same direction, is 11 mm.

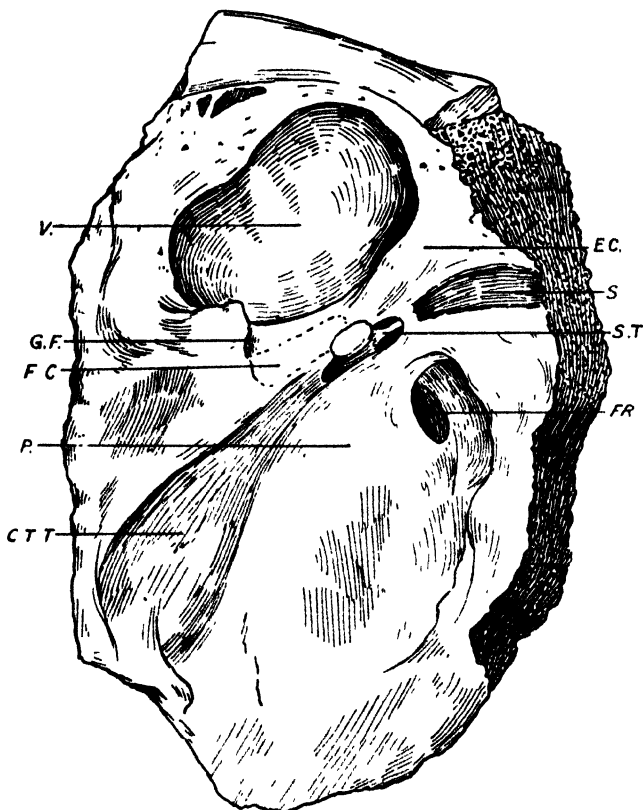
The roof of the tympanic cavity is on a considerably higher plane than that of the bony meatus, and its floor is considerably below the floor of the meatus and, therefore, its three essential divisions are strongly marked.

Thus the vault is sharply divided from the atrium by the Fallopian canal,

and the atrium from the hypotympanic space by the lower margin of the annulus.

The tympanic wall of the Fallopian tube is wanting from a point near the Glaserian fissure to one just above the centre of the fossa ovalis, and the facial nerve is exposed for that distance, being separated from the vault by a bony ridge.

Text-figure 1.



The inner wall of the left tympanic cavity of the horse. $\times 3$.

V. Vault. *G.F.* Glaserian fissure. *F.C.* The dotted line shows the extent of the incomplete outer wall of the Fallopian canal. *P.* Promontory. *C.T.T.* Channel in which the tensor tympani muscle lies. *S.* Stapedius muscle, exposed by removal of the bony wall of the excavation in which it lies. *S.T.* Stapedius tendon inserted into the stapes within the fossa ovalis. *F.R.* Fenestra rotunda. *E.C.* Salient corresponding to nearly the vertex of the external semicircular canal.

The upper portion of the promontory corresponds to the first whorl of the cochlea, and on its summit, looking backwards and upwards, is the aperture of the fenestra rotunda, almost circular in form, and of a mean diameter of 2.5 mm.

The fenestra is closed by the secondary tympanic membrane, stretched across it a little distance below its mouth.

The fossa ovalis, the mouth of which has an upward and forward direction, penetrates the bone for a distance of 3 mm. before reaching the fenestra ovalis, which forms its base.

Chauveau (Fleming's translation) (3) gives the average diameters of the fenestra ovalis as .004 by .002 mm., which is obviously an error which was overlooked, but Lesbre gives the mean measurements as 4 mm. in length by 2 mm. in width. I have found that in light draught adult horses the fenestra is usually 4.30 mm. by 2 mm.

In the foal, at the time of normal birth, of the same class of horse, the length is already 4 mm. by 2 mm., showing the relatively small differences in the size of this structure between the newly-born and the adult.

In the lighter and smaller breeds of horses the length is only slightly less, and I have seldom found the width less than 2 mm.

In the sheep the fenestra ovalis has a mean measurement of 2.10 mm. as to length and 1.5 as to width.

The fenestra rotunda of the sheep is relatively larger than that of the horse, having a mean diameter of 2 mm.

The inner wall of the vault in the horse at its posterior and lower part, just above the salient formed by the Fallopiian canal, shows a well-marked fossa incudis. This is a nearly circular, shallow, cup-like cavity with slightly raised edges, which is lined with hyaline cartilage. It receives the facet found on the inner side of the extremity of the processus brevis of the incus, which is also covered with hyaline cartilage. The facet is attached to the fossa incudis by a fine capsular ligament, and this attachment evidently allows of free movement of the ossicle in any direction.

In the sheep the processus brevis does not show any inner facet as described in the horse, but its rounded extremity is attached to an extremely shallow fossa incudis which possesses no raised margins.

The term "processus brevis" is retained here merely for clearness, as in the sheep the process is actually longer than the processus longus, though in many mammals it is truly shorter.

The Fallopiian canal in the sheep is entirely open on the inner wall of the tympanum from a point just above the Glaserian fissure to an opening in the posterior wall of the cavity above and well behind the opening of the fenestra rotunda, and therefore the facial nerve is entirely exposed for this distance. During this exposure the nerve lies separated from the vault by a prominent shelf-like bony ridge. At the posterior third of this open canal there is a transverse and deep excavation in to the bony wall which lodges the stapedius muscle, and therefore this muscle for a short distance lies immediately below and in contact with, the facial nerve. There is no eminentia pyramidalis in the sheep.

In the horse the outer wall of the tympanic cavity is formed largely by the tympanic membrane, completed above by the dense outer wall of the vault and below by the hard, shell-like outer wall of the hypotympanic space.

The anterior wall of the tympanum consists of the rounded anterior wall of the vault, which corresponds to the anterior part of the head of the malleus, that of the atrium, which unites with the inner wall to form the space for the lodgment of the tensor tympani muscle, and that of the hypotympanic space, the chief feature of which is the opening of the eustachian tube.

THE AUDITORY OSSICLES.

The following remarks only refer to the auditory ossicles of the horse, as a description of those of the domestic sheep has been already published (Wilkie, 9).

In the figures, the drawings of the ossicles of the sheep are given with those of the horse for the sake of comparison. The auditory ossicles of the horse have not hitherto been fully described, so far as I am aware, but Doran's description of them, so far as it extends, most nearly agrees with my results.

He does not, however, indicate the dimensions either absolutely or relatively, and some of his results, as pointed out below, are at variance with my own. The very small illustrations given in his otherwise fine work do not agree morphologically with my observations.

Much larger and more finished drawings of the ossicles of the horse were published first in Chauveau's original work, and reprinted in the two English editions translated by Dr. George Fleming. They were again reprinted in Lesbre's more recent (1922) 'Précis,' but neither the forms nor the relative sizes of the ossicles agree with my observations.

Actually the very small outline drawings of the ossicles given by Bradley (1) are more in conformity with my results than any others I have seen.

Although I know of no recorded reference to the internal structure of the ossicles of the horse or the sheep, the existence of a medullary canal in the ossicles of some of the higher mammals has been in the past both asserted and questioned.

Observations made during the present study have shown that there is no medullary canal, properly so called, in the ossicles of either the horse or the sheep.

In the malleus of the horse, however, there are large medullary spaces in the head of the bone, especially in the foal, but less extensive in the adult.

In the incus of the foal there are smaller but well-marked medullary spaces in the body of the ossicle, and often, also, in the crura.

The stapes of the horse shows no medullary spaces, and none of the ossicles of the sheep have any appreciable ones.

Apart from the medullary spaces mentioned, the ossicles consist most largely of compact tissue.

THE MALLEUS. (Text-figs. 2-4.)

The most striking features of the malleus of the horse are the large head, the deep, sigmoid flexure of the neck, the small, nearly straight processus gracilis, and the small but perfectly-formed lamina.

The mean length of the ossicle from the summit of the head to the processus brevis is 7 mm., and that from the processus brevis to the free extremity of the manubrium is 6 mm.

The manubrium forms, with the neck, two different angles, that along the anterior face being 50° and that along the inner face 32° .

The large articular surface is surrounded on all but its lower border by a prominently-raised rounded margin.

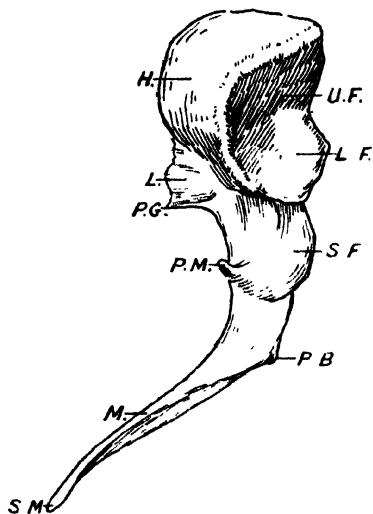
This surface consists of two facets, the upper of which is the larger and nearly plane, while the lower shows a well-marked central salient.

The articular surface faces posteriorly, and is slightly turned to the inner side.

The large, nearly globular portion of the head anteriorly situated to the articular surface shows near its summit a very small, rounded depression for the insertion of the suspensory ligament.

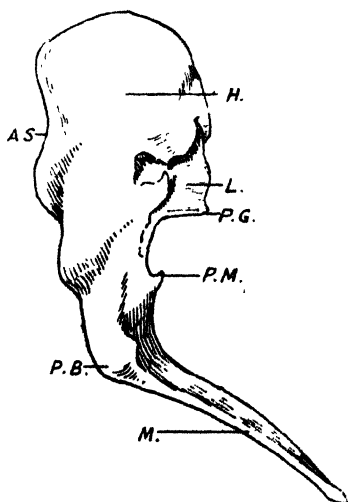
The processus gracilis (anterior process of Bradley) is pointed, and proceeds from the anterior face of the neck almost at a right angle, curvature being nearly absent. It is an extremely short process, having a total length of about 1 mm. Its shortness and straightness are its essential characteristics,

Text-figure 2.

The right malleus of the horse, inner aspect. $\times 7$.

H. Head. *U.F.* Upper articular facet. *L.F.* Lower articular facet. *L.* Lamina. *P.G.* Processus gracilis. *P.M.* Processus muscularis. *S.F.* Inner part of the sigmoid flexure. *P.B.* Processus brevis. *M.* Inner edge of the manubrium. *S.M.* Spatulate extremity of the manubrium.

Text-figure 3.

The right malleus of the horse, outer aspect. $\times 7$.

H. Head. *A.S.* Articular surfaces. *L.* Lamina. *P.G.* Processus gracilis. *P.M.* Processus muscularis. *P.B.* Processus brevis. *M.* Outer edge of the manubrium.

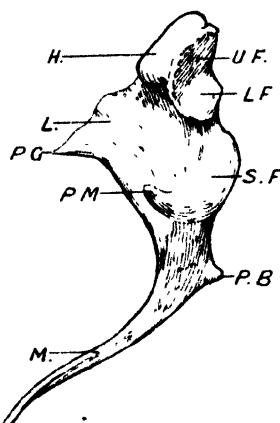
and this observation is at variance with Doran, who says "it is long and sickle-shaped." The straightness of the process in the horse is reminiscent of that of the *processus folianus* of the human subject at birth, although there the process is much longer.

The lamina is small, but extends well up on the anterior face of the head, and its free margin is uneven, usually presenting two, but sometimes only one, broad points.

Although small, the lamina is a well-marked and complete structure, and this does not appear to agree with Doran's observation that "there is little trace of a lamina" (4).

The *processus muscularis* is the terminal point of the sweep of the sigmoid flexure on the inner and lower side of the neck of the malleus, having an upward and forward direction. It protrudes from the neck of the ossicle, as to its upper face, for a distance of 0.5 mm., and as to its lower face from the root of the manu-

Text-figure 4.



The right malleus of the sheep, inner aspect. $\times 7$.

H. Head. *U.F.* Upper articular facet. *L.F.* Lower articular facet. *L.* Lamina. *P.G.* *Processus gracilis*. *P.M.* *Processus muscularis*. *S.F.* Inner part of the sigmoid flexure. *P.B.* *Processus brevis*. *M.* Inner edge of the manubrium.

brium for a distance of 1.5 mm. It is a process of capital importance, as, following the most common, but not invariable (Wilkie, 10), mammalian type, it affords attachment for the tendon of the tensor tympani muscle.

In the ass the *processus muscularis* is larger than in the horse, and may be regarded as an important distinction between the two equine races.

The *processus brevis* is a well-rounded tubercle on the summit of the outer edge of the manubrium, well bent forward, as described by Doran, and forms the upper limit of the attachment of the manubrium to the drum.

The manubrium is 2 mm. in breadth (from the inner to the outer edge) at its base, and extends with a graceful double curvature to a fine point which terminates in a spatulate extremity. The outer edge of the manubrium is slightly thinner than the inner.

The anterior face of the manubrium in front of the *processus brevis* is well hollowed out, but its opposite and posterior face is convex.

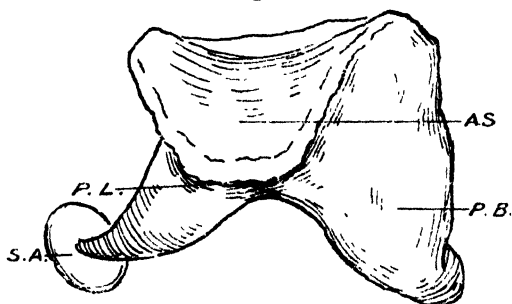
The insertion of the lamina, from the outer face of the ossicle, shows an

interesting formation which, although it is most strongly marked in the newly-born foal, persists in a lesser degree to old age, except, of course, in those cases, which are not infrequent, where the periosteum has been affected with calcareous deposits.

THE INCUS. (Text-figs. 5-8.)

This is a relatively large ossicle, and, as Doran says, "it is very much larger absolutely and proportionally than that of the Rhinoceros." It consists of a large body and two crura, the superior of which is particularly massive.

Text-figure 5.

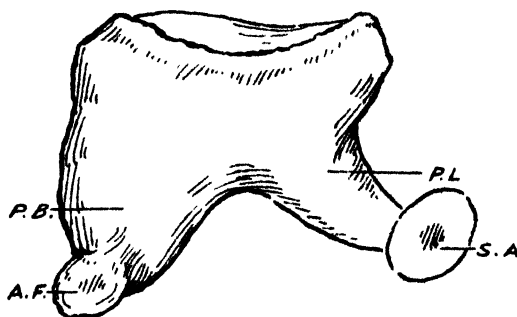


The left incus of the horse, outer aspect. $\times 10$.

A.S. Articular surface. P.L. Processus longus or inferior crus. P.B. Processus brevis or superior crus. S.A. Sylvian apophysis.

The position of the ossicle in the tympanum is that, while its articular surface has an anterior and outer aspect, its upper crura, or processus brevis, articulates with the fossa incudis on the posterior inner and lower part of the vault,

Text-figure 6.



The left incus of the horse, inner aspect. $\times 10$.

P.L. Processus longus or inferior crus. P.B. Processus brevis or superior crus. A.F. Articular facet. S.A. Sylvian apophysis.

and the processus longus passes over the Fallopian canal into the atrium to reach the head of the stapes.

The average length of the body of the incus, from above downward, is

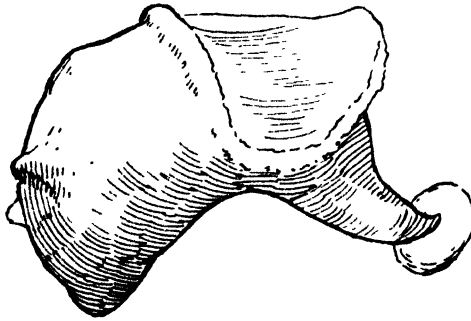
4 mm., and the depth of the body (transversely when the ossicle is *in situ*) is 2.50 mm.

The processus brevis is large, with an upper margin showing two rounded elevations and a lower margin which curves from its base, the process ending in a pointed free extremity.

The base or root of the process has a width of 2.80 mm.

On the inner side of the extremity of the processus brevis is a structure

Text-figure 7.

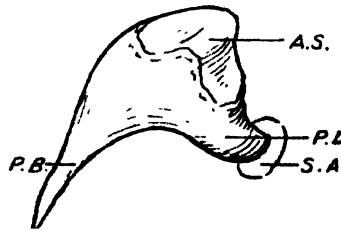


The right incus of the horse, aberrant form, outer aspect. $\times 10$

of capital importance, but to which I have not been able to find any previously recorded reference.

This is an ovoid convex facet the axis of whose long diameter has an inclination downward and forward. The facet is well raised above the surface of the process, and articulates with the fossa incudis in the wall of the vault.

Text-figure 8.



The right incus of the sheep, outer aspect. $\times 10$.

A.S. Articular surface. P.L. Processus longus or inferior crus. P.B. Processus brevis or superior crus. S.A. Sylvian apophysis.

The processus longus of the incus of the horse is actually of the same length, from base to extremity, as the processus brevis, viz. 3 mm., but the term is retained to designate the inferior crus, because it is so commonly the longer in mammalian anatomy that it is, perhaps, most generally understood by that designation.

The processus longus is much narrower at its base than the processus brevis, being rarely more than 1.80 mm. It is more rounded in contour, and it curves downwards, inwards, and backwards to a pointed extremity.

While the divergence of the processus brevis from the body is small, that of the processus longus is far greater.

The inner face of the processus longus has attached to it the oval, disc-like, Sylvian apophysis, the long diameter of which is rather less than 2 mm.

The long axis of the Sylvian apophysis has an inclination downwards and forwards.

It is, I believe, rare to find a completely ossific union between the Sylvian apophysis and the processus longus, but it is found to be partially ossific in the newly-born foal, and often no more than that in old horses.

The malleo-incudal articular surface of the incus consists of two facets separated by a well-marked ridge: the smaller of these is anteriorly situated on the ossicle, and the larger extends down the outer side of the body of the bone, well down towards the root of the processus longus.

The incus of the horse has, however, an aberrant form which is common enough in both foals and adults. The main feature of this form is a very extensive development of the processus brevis, the bulging upper surface of which is provided with one, or sometimes two, centrally-situated pointed elevations. Usually one of these pyramidal elevations is on the outer surface, and one often, also, on the upper.

The width of the base of the process in such an aberrant form may be 3.50 mm. or even more, while the rest of the ossicle is of normal development.

THE STAPES. (Text-figs. 9-11.)

This is of the usual somewhat stirrup-shaped type, but not of the rounded arched form common in many of the Carnivora and the Insectivora, or the higher arched form of many of the Rodentia. It is of the rectangular type, less triangular than that of the domestic sheep, and less rectangular than that of the domestic ox.

Doran considered the stapes of the horse to be "quite triangular, with extremely straight crura." However, the mean dimensions I have found for this ossicle are the following:—

| | |
|--|----------|
| Height from base to capitulum | 4 mm. |
| Long diameter of the head | 2 mm. |
| Long diameter of the base | 3.50 mm. |
| Width of the base | 1.80 mm. |
| Long diameter of the intercrural aperture | 2 mm. |
| Width of the intercrural aperture | 1.50 mm. |
| Anterior and posterior crura of equal length | 2 mm. |

The position of the stapes as it lies within the fossa ovalis is downwards, inwards, and backwards, making an angle of 55° with the vertical line of the tympanum. The ossicle has a well-marked head, which is lower on the upper and posterior border than on the anterior, and this lower side overhangs the crus slightly.

Just beneath the head, on the upper side, a small tubercle exists on the outer and under side for the insertion of the tendon of the stapedius muscle.

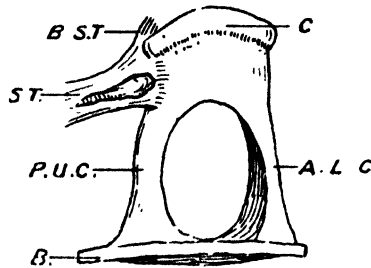
The base of the stapes is of substantial thickness, with rather square-cut margins, and it extends considerably farther beyond the insertion of the posterior crus than it does beyond the anterior.

The vestibular surface of the base is slightly convex, but not sufficiently so as to constitute a distinct umbo.

Ellenberger and Müller (5) give the length of the base of the stapes as 3 mm. and its width 2 mm. I have not found the length to be so little as 3 mm.

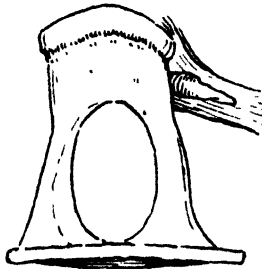
even in the newly-born foals, and the width has only been found to reach 2 mm. in the larger breeds. It appears, however, to be a fact that the dimensions of the auditory ossicles are not very materially less in the newly-born foal than they are in the adult.

Text-figure 9.

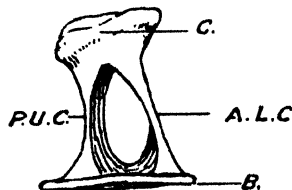
The stapes of an aged horse, inferior aspect. $\times 8$.

C. Capitulum. *B.S.T.* Branch of the stapedius tendon, which becomes inserted into the rim of the Sylvian apophysis. *S.T.* Stapedius tendon, showing its ossicles *in situ*. *P.U.C.* Posterior and upper crus. *A.L.C.* Anterior and lower crus. *B.* Base.

Text-figure 10.

The stapes of an aged horse, superior aspect. $\times 8$.

Text-figure 11.

The stapes of a sheep, inferior aspect. $\times 10$.

C. Capitulum. *P.U.C.* Posterior and upper crus. *A.L.C.* Anterior and lower crus. *B.* Base.

As is well known, the foal at birth is in a much more advanced state of physical development than is the case in the newly-born of many other species of animals, but the auditory ossicles of the foal are much larger in relation to the size of the animal than they are in the adult.

THE MUSCLES AND LIGAMENTS OF THE OSSICLES.

The tensor tympani muscle is of considerable size, and arises in a large, open excavation made up partly by the anterior wall and partly by the inner wall of the atrium, and situated anteriorly to the promontory. It terminates in a strong tendon which has a powerful insertion into and around the point of the processus muscularis of the malleus.

The anterior ligament of the malleus has a firm attachment to the processus gracilis, and enters the Glaserian fissure. It does not, apparently, pass completely through the fissure, but finds its attachment within it as well as to the tympanic opening of the fissure.

The posterior ligament of the malleus arises from a broad base of attachment to the outer wall of the vault, and becomes smaller and rounder as it approaches its insertion into the neck of the malleus slightly to its posterior face and nearly opposite the level of the terminal point of the processus muscularis.

The suspensory ligament of the malleus is a very fine, round ligament, and arises from the anterior part of the roof of the vault. It is inserted into a very shallow circular depression in the head of the malleus.

The depression in the head of the malleus for the insertion of the ligament is sometimes only just perceptible, although in other specimens it may be well marked.

I have found no suspensory ligament of the incus in the horse, but there is commonly a descending fold of mucous membrane between the upper part of the body of the incus and the roof of the vault, examinations of which have not shown any ligamentous fibres.

The ligament attaching the incus to the fossa incudis has already been noticed in dealing with the structure of the vault.

THE STAPEDIUS MUSCLE.

This lies in a bony excavation in the inner and the posterior wall of the tympanum which lies immediately below the Fallopiian canal, and from its base has a downward, forward, and outward direction, with a slightly curved contour. This excavation opens by a small aperture within the fossa ovalis on its posterior face, and there is no eminentia pyramidalis. The muscle is of important size, and terminates in a rather long, round tendon which reaches its insertion into the tubercle on the posterior crus of the stapes just within the cavity of the fossa ovalis. Before reaching its insertion it gives off a small and frail branch which passes across the margin of the head of the stapes to become attached to the rim of the Sylvian apophysis of the incus.

The stapedius muscle is from 5 to 6 mm. in length. Chauveau says "it terminates by a small tendon in front of the stapes." This is a position in which I have never found it.

The tendon of the stapedius contains within its substance a club-shaped ossicle of which the larger, rounded head is in close contact with the tubercle on the stapes. (Text-fig. 12.)

This ossicle was described by Chauveau as a bony nucleus, of which no shape is given in the text; but in his illustration of it, it appears as an oval body enclosed in a fan-shaped tendon. I have never seen it assume this form, and the tendon, according to my observations, is never fan-shaped, but long and rod-shaped.

The club-shaped ossicle has been found in all my material fully formed at birth, and I have been fortunate enough to secure a pre-natal specimen in which the ossicle is in process of formation from a single centre of ossification

which is situated in the larger end of the ossicle. The ossicle is not, therefore, the result of an ossification of the tendon in old age, but, on the contrary it is found to be larger at the time of birth than in old horses.

In old horses the large end is undiminished in size, but the small one is shorter, the average length of the ossicle being 1.02 mm., while in foals of the same breed (light draught horses) it commonly reaches nearly 2.0 mm. in length.

(Chauveau mentions that a bony nucleus also occurs in the stapedius tendon of the sheep.

My observations on the sheep have been nearly all confined to British breeds and to sheep not exceeding two and a half years of age. In these there is no bony nucleus to be found in the tendon of the stapedius in any specimen I have examined.

It is possible that some ossification of the tendon may occur at times in old rams or ewes, and it is also probable that Chauveau's observations were made on sheep of other than British breeds.

Text-figure 12.



The ossicle of the stapedius tendon as it occurs in the foal. $\times 35$.

H. Head, which is in close contact with the tubercle on the posterior and inferior face of the stapes immediately below the capitulum. *E.* Caudal extremity of the ossicle, which is twisted upon itself.

It appears that the presence of the club-shaped ossicle in the stapedius tendon of the horse, occurring as it does in a fully-formed condition in the newly-born foal, has some greater significance than a mere ossification of the tendon, especially as it does not progress to further development in the adult, but tends, rather, to diminution in size in old age.

It may therefore be suggestive of the persistence of an ancestral remnant, as Prof. Huxley pointed out many years ago, that the stapes and its appendages are exclusively related to the hyoidean arch.

The ligaments connected with the articulations of the malleus and incus and the incus and stapes need not be referred to, as they have been exhaustively dealt with by several authors.

The nerve supply and circulation have not been referred to, being more conveniently dealt with in the second part of these notes.

A considerable quantity of material from different sources has been used in this investigation and my thanks are specially due to Mr. F. T. Harvey, F.R.C.V.S., of St. Columb, Cornwall, for valuable specimens from foals.

WORKS REFERRED TO.

1. BRADLEY, O. C. 1923. *The Topographical Anatomy of the Head and Neck of the Horse*, p. 157. Edinburgh.
2. CHAUVEAU, A. 1871. *Traité d'Anatomie Comparée des Animaux Domestiques*, p. 887. Paris.
3. CHAUVEAU, A. (FLEMING'S ed.). 1891. *The Comparative Anatomy of the Domesticated Animals*, second edition, p. 952. London.
4. DORAN, A. H. G. 1876. *The Morphology of the Mammalian Ossicula Auditus*. *Trans. Linn. Soc.* 2nd series, vol. i. Zoology, pp. 420-421. London.
5. ELLENBERGER, W., & MÜLLER, C. 1896. *Handbuch der Vergleichenden Anatomie der Haustiere*, p. 852. Berlin.

6. HUXLEY, T. H. 1869. Proc. Zool. Soc. London, pp. 391-407.
7. LESBRE, F. X. 1922. Précis d'Anatomie Comparée des Animaux Domestiques, p. 241. Paris.
8. SISSON, S. 1917. The Anatomy of the Domestic Animals, pp. 875-878. Philadelphia.
9. WILKIE, H. C. 1925. The Ossicula Auditus of the Sheep (*Ovis aries*). Journal of Comparative Pathology, pp. 298-301. Edinburgh.
10. WILKIE, H. C. 1929. The Attachments of the Auditory Ossicles of the Common Mole. Proc. Zool. Soc. London, p. 63.

8. The Spiders of the Island of Grassholm, and some Additions to the Skomer Island List (South Wales). By W. S. BRISTOWE, B.A., F.Z.S.

[Received August 10, 1930 : Read February 17, 1931.]

Grassholm is a tiny island, with a diameter of about a quarter of a mile, lying six miles outside Skomer Island and about nine from the Pembrokeshire coast. The exposed side of the island is almost completely monopolized by gannets. The remainder of the island does not support a very varied flora, but is covered for the most part by a tough thin-leaved grass. Similarly, and largely, no doubt, as a result of this, coupled with the greater exposure to which it is subjected, the fauna is small compared with that of Skomer. On Grassholm, for instance, I only noticed one species of ant, *Myrmica* sp., as compared with six on Skomer*. Half a day was spent there on June 9th, 1930, and in the course of this time a collection of spiders comprising 11 species was made.

There appeared to be no Epeirids present on Grassholm. That *Zilla x-notata* is absent can probably be attributed to the fact that no one has ever lived on the island, for I have shown elsewhere that this species is normally transported by man †, but the absence of *Meta merianæ* is somewhat surprising. Still more unexpected is the absence of *Tetrax denticulata*, which usually seems to flourish near the sea and in chinks in rock-faces on islands. Have even its powers of resistance to exposure been overcome on this tiny islet, which is undoubtedly drenched with spray from end to end in stormy weather?

My captures were as follows :—

Segestria senoculata Linn.

Oonops pulcher Templ.

Drassodes lapidosus Walck. In two cases mature males sharing a cell with an immature female.

Xysticus kochii Thor.

Lepthyphantes tenuis Bl. Abundant.

Gongylidiellum vivum Camb. Females with their round white egg-cocoons under stones in very damp ground.

Wideria antica Wid.

Tiso vagans Bl. Under stones and in gulls' nests.

Lophocarenum parallelum Sim. In a gull's nest.

Lycosa pullata Clerck Abundant.

Trochosa terricola Thor. Both sexes, some of the females with

Of these, *Gongylidiellum vivum* Camb. has not yet been found on Skomer.

In a recent paper (Proc. Zool. Soc. pt. 4, 1929, p. 617) I recorded 67 Spiders, 2 Phalangids, and 1 Chelifer from Skomer Island. A further brief visit was paid

* H. M. Hallett, Cardiff Nat. Soc. Trans. p. 72, 1930.

† Proc. Zool. Soc. pt. 4, 1929, p. 655.

there in June 1930, and in the course of June 8th and part of the following day 14 additions to the list were made. As two of these replace immature and doubtful specimens included in the previous list, namely, *Zelotes* sp. and *Phalangium* sp., the total records now comprise 77 Spiders, 3 Phalangids, and 2 Chelifers. The additions are as follows :—

| | |
|--|----------------------------|
| <i>Dictyna latens</i> Fabr. | Amongst heather. |
| „ sp. (imm.) | Amongst heather. |
| <i>Chiracanthium carnifex</i> Fabr. (imm.) . | Amongst nettles. |
| <i>Zelotes latreillii</i> Sim. | Under stones, N. Haven. |
| <i>Phrurolithus festinus</i> C. L. K. | N. Haven. |
| <i>Walckenaera acuminata</i> Bl. | Marsh. |
| <i>Hypomma bituberculata</i> Wid. | Marsh. |
| <i>Pocadicnemis pumila</i> Bl. | Marsh. |
| <i>Oreonetides abnormis</i> Bl. | Male and female, N. Haven. |
| <i>Epeira adianta</i> Walck. (imm.) | Amongst heather. |
| <i>Tegenaria atrica</i> C. L. K. | In an outhouse. |
| <i>Megabunus diadema</i> Fabr. | |
| <i>Platybunus triangularis</i> Herbst. | |
| <i>Obisium muscorum</i> Leach | Under a stone. |

In a shag's nest of rather drier consistency than is usual, and composed partly of thrift, I found *Harpactes hombergii* Scop. and *Lophocarenum nemorale* Bl.

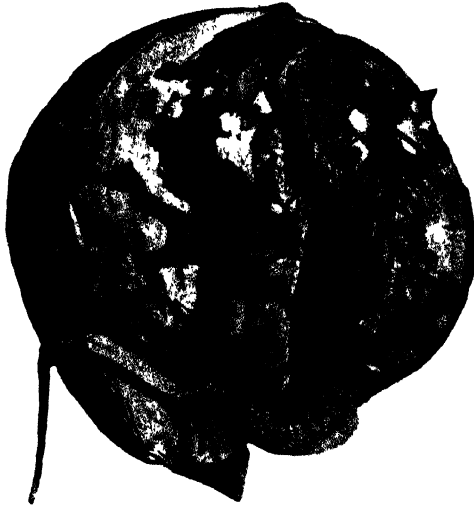
North Haven and the Neck differ geologically from the main part of the island, being composed of breccias, quartzites, and Skomerite—a basaltic rock to which the island has given its name. It also happens to be somewhat more sheltered than the rest of the island, and several species appear to be restricted to this part of it—*Zelotes latreillii*, *Phrurolithus festinus*, *Micaria pulicaria*, and *Heliophanus flavipes* for instance.

In the course of my visit, brief though it was, I found the majority of the species included in my earlier collection. *Textrix denticulata* and *Meta segmentata* males were courting their females, some of the *Segestria senoculata* females had laid their eggs (about 50 yellow eggs in a silken sac), and a *Harpactes hombergii* female was found with 20 pinkish-orange eggs. Clusters of young *Epeira diademata* were seen, but the majority had scattered and were building their first orb-webs. An immature *Theridion denticulatum* was observed trussing up a male *Salicicus scenicus* which had inadvertently trespassed on its preserves.

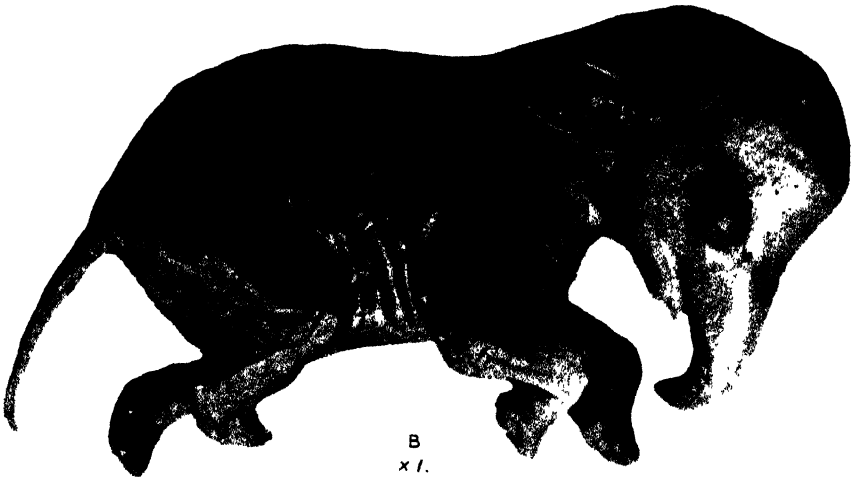
In my last paper I gave a list of a few species collected at Haverfordwest and at Marloes, close to the coast opposite Skomer. Owing to the roughness of the sea I was forced to spend one day at Marloes before I was able to cross to Skomer on June 8th, so I can now supplement my previous list by the addition of 35 species. For the most part the Spider fauna of the coast adjoining Skomer resembles that of the island, but the most notable exceptions are *Agelena labyrinthica* Clerck, *Pisaura mirabilis* Clerck, and *Epeira umbratica* Clerck, all of which were found by the boat-house within a stone's throw of the sea. In addition, there is *Dysdera crocata* C. L. K., which I found, though not commonly, on the cliffs at Marloes, and *Epeira cornuta* Clerck amongst rushes at Haverfordwest. As before, H. stands for Haverfordwest and M. for Marloes in the

list which follows, whilst those enclosed in brackets were recorded in my previous list, but not from the same locality :—

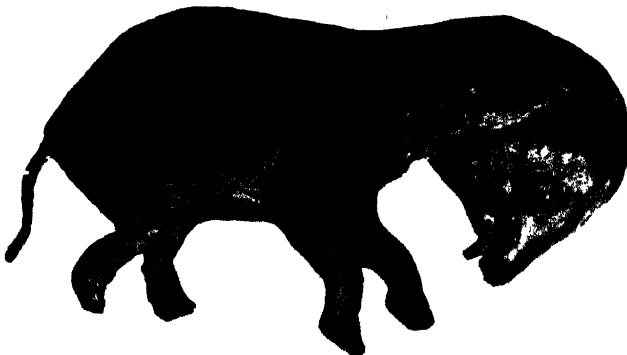
| | |
|--|--|
| <i>Segestria senoculata</i> Linn. M. | <i>Epeira cornuta</i> Clerck H. |
| <i>Dysdera crocata</i> C. L. K. M. | <i>Zilla x-notata</i> Clerck M., H. |
| <i>Drassodes lapidosus</i> Walck. M. | (<i>Meta merianæ</i> Scop. M., H.) |
| „ <i>troglydites</i> C. L. K. M. | (<i>Pachygnatha degeerii</i> Sund... M.) |
| <i>Xysticus cristatus</i> Clerck M. | <i>Tetragnatha extensa</i> Linn. ... H. |
| <i>Clubiona grisea</i> L. K. M. | <i>Dictyna latens</i> Fabr. M. |
| <i>Chiracanthium carnifex</i> Fabr. ... M. | <i>Ammaurobius fenestralis</i> Stroem. H. |
| <i>Micaria pulicaria</i> Sund. M. | (<i>Agelena labyrinthica</i> Clerck.. H.) |
| <i>Phrurolithus festivus</i> C. L. K. ... M. | <i>Tetrax denticulata</i> Oliv. M. |
| (<i>Pholcus phalangoides</i> Fuess. ... M.) | <i>Pirata piratica</i> Clerck H. |
| <i>Enoplognatha thoracica</i> Hahn ... M. | <i>Trochosa terricola</i> Thor. H. |
| <i>Bathypantes approximatus</i> Camb. M. | <i>Lycosa nigriceps</i> Thor. M. |
| <i>Stemonyphantes lineatus</i> Linn. .. M. | „ <i>monticola</i> C. L. K.... M. |
| <i>Erigone longipalpis</i> Sund. M. | („ <i>amentata</i> Clerck M.) |
| <i>Pæciloneta globosa</i> Wid. M. | („ <i>pullata</i> Clerck M.) |
| <i>Wideria antica</i> Wid. M. | <i>Tarentula pulverulenta</i> Clerck. M. |
| <i>Entelecera erythropus</i> Westr. M. | (<i>Pisaura mirabilis</i> Clerck ... M.) |
| <i>Pocadicnemis pumila</i> Bl. M. | <i>Euophrys frontalis</i> Walck. ... M., H. |
| <i>Savignia frontata</i> Bl. M. | <i>Sallicus scenicus</i> Clerck M., H. |
| <i>Gnathognarum dentatum</i> Wid. ... M. | (<i>Nemastoma lugubre</i> Müll. ... M.) |
| <i>Agyneta conigera</i> Camb. M. | <i>Chthonius rayii</i> L. K. M. |
| <i>Epeira diademata</i> Clerck M. | |



A $\times \frac{2}{7}$



B
 $\times 1$.



C
 $\times \frac{1}{3}$.

9. The Development of the Mandible in the Elephant. By NELLIE B. EALES, D.Sc.(Lond.), C.M.Z.S., Lecturer in Zoology in the University of Reading.

[Received October 2, 1930. Read February 3, 1931.]

(Plate I.*; Text-figures 1-9.)

During the past six years I have been studying the anatomy of the Proboscidea by dissecting foetal specimens under the binocular dissecting microscope. Altogether three foetuses have been investigated, of which number only one was sufficiently well preserved to allow of detailed examination of the soft parts. The results of these studies have been published in the 'Transactions of the Royal Society of Edinburgh' in 1926, 1928 and 1929 respectively.

In the first of these papers attention was directed to the remarkable appearance of the mandible in the foetal condition, and the study of the second and third foetuses, together with a comparison with post-natal stages, enables us to trace, in a general way, the development of the elephant's mandible.

The material is as follows:—

Foetus 1 is an African foetus, 21 cm. long from forehead to root of the tail (Pl. I., A). It is fairly well preserved, and is probably about ten months old, or a little less than half term. It was obtained by purchase from two Belgians, who secured the specimen in the Belgian Congo. The specimen was described and figured in the 'Proceedings of the Zoological Society,' 1925.

Foetus 2 is also an African foetus (Pl. I., B). It belongs to the British Museum (Natural History), and was loaned to me on condition that I dissected half of it only. It is 9.5 cm. from forehead to root of the tail, and is in a poor state of preservation as regards the soft parts.

Foetus 3 (Pl. I., C) is an Indian foetus which also belongs to the Natural History Museum, and was loaned to me on the same conditions as Foetus 2. It measures only 6.8 cm. from forehead to root of the tail, and is very badly preserved. It was figured and described by Gray in the 'Proceedings of the Zoological Society,' 1868.

For comparison with these foetal stages I have used the skeleton of an adult African elephant in the Natural History Museum and two young specimens from the Royal College of Surgeons Museum. The first R.C.S. specimen, numbered 2496 in the Catalogue, was six months old at death, and the second, numbered 2495, was, at most, only a few days old. Of the six stages used in this paper, therefore, five are African, and one, the youngest of all, is Indian. Placing the specimens in order according to their age, there are adult, six months old, just-born, half-term, and less than half-term African specimens, and a very young foetal Indian specimen. These form a fairly comprehensive series, the largest gap being during the second half of pregnancy.

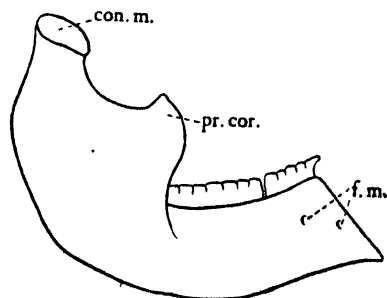
I wish to express my thanks to Professor F. J. Cole, F.R.S., in whose laboratory the work has been done, for his ready criticism and advice. To the Trustees of the Natural History Museum I am indebted for the loan of two

* For explanation of the Plate, see p. 125.

of the three foetal specimens, and I am grateful to Dr. W. Calman, F.R.S., and Mr. M. A. C. Hinton, F.Z.S., for allowing me access to their stored material. Mr. R. H. Burne, F.R.S., helped me with the Royal College of Surgeons material, and I should like to record my gratitude to him.

The present paper deals with the mandible of the six elephants quoted above. In the adult condition (text-fig. 1) note the following points. The unique general shape is due to the relatively short horizontal plane and very high vertical plane. The proportion of height to length in the specimen figured is 1 : 1.3. The *shortening* of the jaw has been brought about by the disappearance of the pre-alveolar border and enlargement of the premolar and molar teeth. We know the reason of this shortening if we examine the upper jaw, for the latter projects beyond and covers the lower jaw, the great tusks extending forwards (text-fig. 6). Note the position of the mental foramina and of the low, spout-like symphysis (text-fig. 8). The increase in *height* has been due to the growth of the ramus of the mandible between the condyle

Text-figure 1.



Adult African Elephant. Lateral view of right half of the mandible, drawn from a photograph. $\times \frac{1}{2}$.
For reference letters to this and subsequent text-figures, see p. 125.

and the angle. The coronoid process appears to have been dragged downwards as the result of this growth. The symphysis is confined to the ventral portion of the body only and is roughly horizontal, or even turned ventrally. Its backward extent is unusual, since it reaches as far as the second tooth in the jaw. The angle between the ramus and the body is rather more than a right angle; the posterior and ventral borders, however, are much curved.

Let us now look backwards in the life of the elephant. Specimen 2496 in the Royal College of Surgeons Museum, according to Flower's manuscript entry in Owen's 'Catalogue of Osteology,' is "the left half of the skull of a young African Elephant. The animal (about three feet high, and supposed to be six months old) was shot by Mr. Baines, Jan. 18, 1862, on the west side of Lake Ngami." The half of the skull was figured by Flower in his 'Osteology of the Mammalia,' but he neither figured nor described the mandible. This structure is shown in text-fig. 2 *a*. Damage to the condylar and angular portions precludes accurate estimates of its length and height, but it is evident that its proportions are very different from those of the adult. It is longer than it is high, but the coronoid process has already been dragged down lower than the condylar level. The most interesting feature, however, is the pre-alveolar region, which is not

sharply cut away anterior to the first tooth as in the adult, but is more like that of other mammals * in that it is turned ventralwards or deflected. Its most anterior point is not yet covered by the upper jaw, though the latter is growing forwards to do so. The small tusk points forwards and ventralwards, and is wholly anterior to the lower jaw. The dorsal border of the tip of the mandible exhibits corrosion of the bone, and this is seen also in the symphysis (text-fig. 8). The angle between the symphysis and the vertical is less than that of E. 1.

Specimen 2495 in the Royal College of Surgeons Museum is the skull and mandible of an African Elephant which died very soon after birth. There are no exact records of its age, but the fact that the cusps of the first lower deciduous

Text-figures 2 a & 2 b.

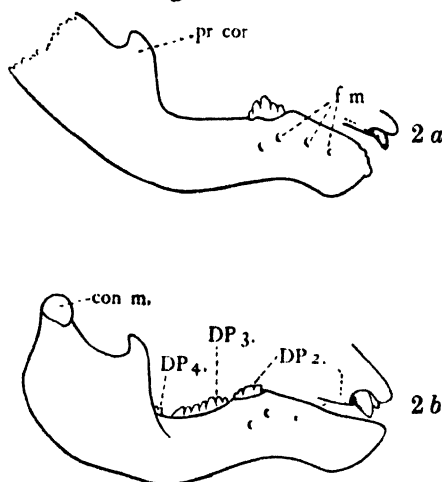


Fig. 2 a. Young African Elephant, about six months old. Lateral view of right half of mandible. The condylar and angular portions are missing. The actual specimen belongs to the left side, but as all the other mandibles have been drawn in right lateral view, this one has been made to conform to the general scheme. $\times \frac{1}{4}$.

Fig. 2 b. Very young African Elephant, just born. Lateral view of right half of the mandible. $\times \frac{1}{4}$.

(In Figs. 2 a and 2 b the positions of the upper jaw and milk-tusk are shown.

In 2 b upper and lower jaws are level; in 2 a the upper jaw projects.)

premolar tooth (DP. 2) are just beginning to flatten indicates that it had a short post-natal existence. In this specimen (text-fig. 2 b) the upper jaw does not overhang the lower jaw, but both reach the same level anteriorly, and the tusks of the upper jaw project *laterally*, i. e., lateral to the mandible, not wholly anteriorly to the mandible, as in the adult. This mandible is twice as long as high, and much of its length is due to the extent of the pre-alveolar region, which slopes downwards and terminates in a normal ovate symphysis, set at an angle of 55° from the vertical. The pre-alveolar dorsal border is not incised or corroded, and the coronoid process is lower than the condyle.

Fœtus 1, the oldest fœtus, exhibits in its mandible a very great deviation from the Proboscidean type. Its characters are partly due to its immaturity,

* Except, perhaps, the Sirenia; but see note on p. 124.

but it retains, also, definite ancestral features in a marked degree. The mandible is 5.6 cm. long and is elongated antero-posteriorly (text-figs. 3 *a*, 3 *b*). It is

Text-figures 3 *a* & 3 *b*.

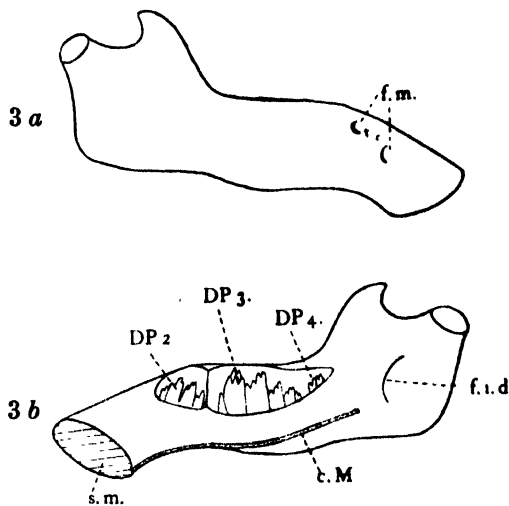


Fig. 3 *a*. Fœtus 1 (African). Lateral view of right half of the mandible. $\times 1$ approx.

Fig. 3 *b*. Mesial view of right half of the mandible. $\times 1$ approx.

Text-figures 4 *a* & 4 *b*.

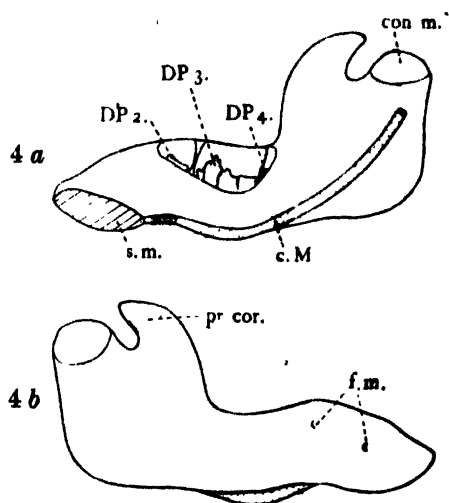


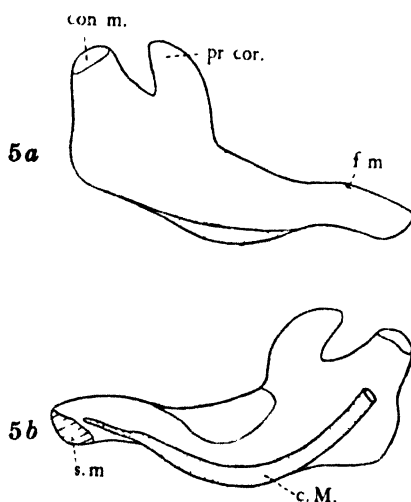
Fig. 4 *a*. Fœtus 2 (African). Lateral view of right half of the mandible. $\times 2\frac{1}{2}$.

Fig. 4 *b*. Mesial view of right half of the mandible. $\times 2\frac{1}{2}$.

much longer than it is high, the proportion of greatest height to greatest length being 1 : 2.8, or nearly three times as long as high. The angle is rather more than a right angle. The coronoid process is elevated above the transverse

condyle, and there is not yet any sign of the abnormal development of the bone between the condyle and the angle. There is a small remnant of Meckel's cartilage (*c.M.*). As in the young post-natal stages, the pre-alveolar region is strongly deflected. The mandible reaches the extreme anterior limit of the premaxilla of the upper jaw. The ovate symphysis is set at an angle of about 50° from the vertical. The age of this foetus is probably about ten months, or nearly half term, since it agrees as regards size, development of hairs, etc., with Toldt's specimen, which was known to be of that age.

Foetus 2 is a younger African foetus, whose mandible is 2 cm. long. What ought we to expect of it? Is it longer or shorter relatively than in the later stage? Does the pre-alveolar border turn downwards, and, if so, is the deflection more or less than in the older foetus? Text-figs 4 *a* and 4 *b* show the mandible of this specimen. It is evident that the jaw has not reached its greatest proportionate length. It is just over twice as long as high, the proportion of

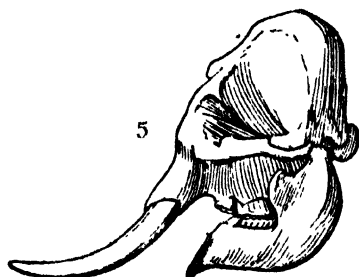
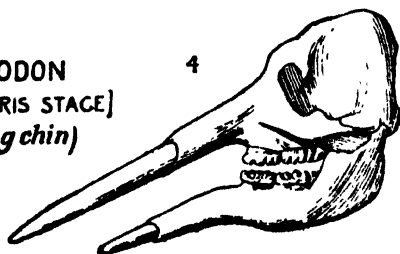
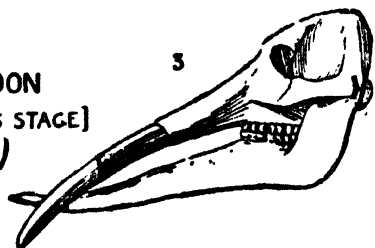
Text-figures 5 *a* & 5 *b*.Fig. 5 *a*. Foetus 3 (Indian). Lateral view of right half of the mandible. $\times 3\frac{1}{2}$ approx.Fig. 5 *b*. Mesial view of right half of the mandible. $\times 3\frac{1}{2}$ approx.

greatest height to greatest length being 1 : 2.1. From the figure it will be seen that the ramus of the mandible is relatively greater in size at this stage than in Foetus 1. The deflected portion, however, has not reached its maximum. In other words, the growth-changes between Fo. 1 and Fo. 2 involve decrease in the relative size of the ramus, especially of the coronoid process, and increase in the relative length of the downwardly-turned pre-alveolar portion of the body of the mandible.

Foetus 3 is an Indian foetus of unknown age. Its mandible, which is only 1.4 cm. long, is not very well ossified, and no teeth are yet formed (text-figs 5 *a*, 5 *b*). The ramus is well developed, with a large and high coronoid process and acute mandibular notch. The body is small. As in the African foetuses, however, it bends ventralwards away from the upper jaw. The proportion of height to length is 1 : 1.9. Meckel's cartilage is very large.

It is now possible to compare these six stages and to gain some idea of the

Text-figure 6.

*Recent**Pleistocene***ELEPHAS**
(short chin)*Upper Pliocene**Lower Pliocene***TETRAELODON**
[LONGIROSTRIS STAGE]
(shortening chin)*Upper Miocene**Middle Miocene***TETRAELODON**
[ANGUSTIDENS STAGE]
(long chin)*Lower Miocene**Upper Oligocene**Migration from Africa
into Europe - Asia*

?

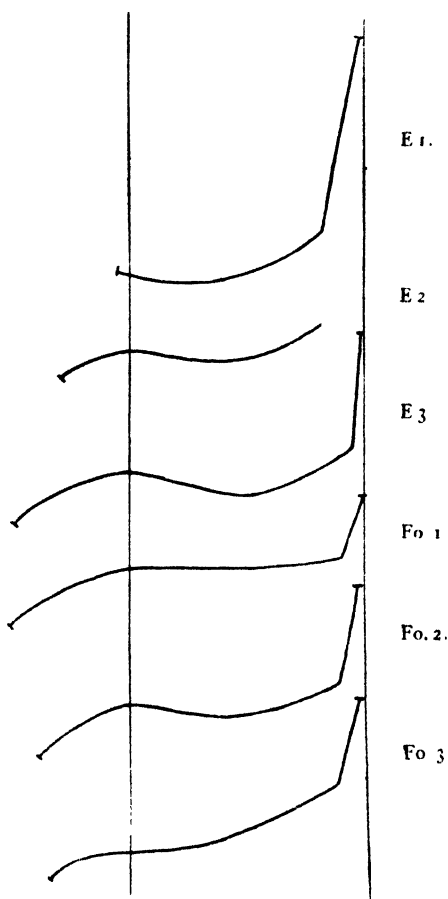
*Lower Oligocene***PALAEOMASTODON**
(lengthening chin)*ditto ditto**Upper Eocene***MOERITHERIUM**
(short chin)*Lower Eocene*

?

Diagram showing some stages in the gradual increase in size, and alteration in form, of the skull and mandible occurring in the Proboscidea from the Eocene to the present day. (Reproduced, by permission of the British Museum Trustees, from the 'B.M. Guide to the Elephants,' 1922.)

development of the mandible before and after birth. Attention has already been drawn to the fact that in the foetal condition the mandible passes through phases which are unlike those of the parent mandible or of any other modern mammalian mandible, but are probably ancestral in character.

Text-figure 7.



The axis of the mandible of the six stages described in the text, for comparison. The two vertical lines pass through the condyle and anterior alveolar border respectively, so that each specimen is reduced or magnified to give the same distance between these two points. The height of the mandible is obtained by drawing the axis of the ramus between the condyle and angle, the length by connecting this line with the axis of the body of the mandible. In this way the relative proportions of height to length are expressed diagrammatically, and the amount of bone anterior to the tooth-sockets can be seen at a glance.

All zoologists know the palaeontologists' deductions regarding the evolution of the order to which the modern elephants belong. Fossil evidence indicates that between the Oligocene and Miocene periods the Proboscidean stock produced forms whose increase in size was coupled with a lengthening of the

skull and jaws (text-fig. 6). *Palæomastodon*, some species of *Tetrabelodon*, and many others belonged to this period. In these animals both jaws possessed tusks, and the lower tusk probably got in the way of the upper tusk. So in the Upper Miocene period, species of *Tetrabelodon* and other giant forms were evolved in which two great changes occurred. The greater usefulness of the upper tusk led to the progressive diminution in size of the lower tusk, and as the upper tusk increased still further, the upper jaw was dragged downwards to support it, and the mandible turned downwards away from the upper jaw. In this position the deflected portion was useless, and so between the Lower Pliocene and recent periods its tusk disappeared and the useless anterior portion of the jaw followed, giving rise to forms like the modern elephants, with short chins and very heavy jaws.

Turning to the modern forms, I have shown that during its development the elephant mandible passes through the same phases, although the lower tusk is not represented.

Firstly, there is, during the gestation period, an increase in the length of the jaw compared with its height, followed by a proportionate shrinkage in length and increase in height (text-fig. 7). Setting out the five specimens in the form of a table (omitting the six months' old African Elephant, because its jaw is imperfect), we have :—

| | | |
|------------|--------------------|--|
| Fo. 3..... | Height : Length :: | 1 : 1.9 |
| Fo. 2..... | " " | 1 : 2.1 |
| Fo. 1..... | " " | 1 : 2.8 (maximum proportionate length) |
| E. 3..... | " " | 1 : 2 |
| E. 1..... | " " | 1 : 1.3 |

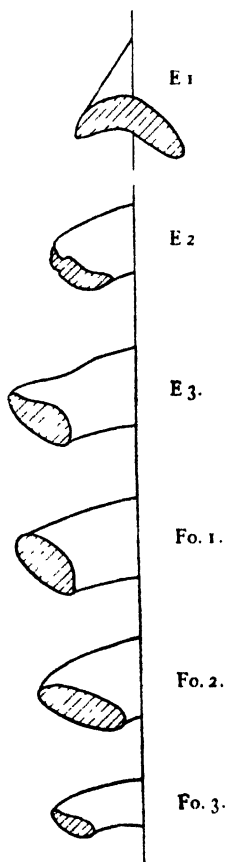
Secondly, the pre-alveolar portion of the mandible, although not yet overhanging by the upper jaw, is deflected. The deflected area increases both relatively and absolutely during the gestation period (text-fig. 9); between the middle and end of this period there is, however, little change in relative length (text-fig. 8). During the first six months of free existence there is both a relative and absolute shrinkage in length of the pre-alveolar portion of the mandible, culminating in the formation of the triangular shape of the adult.

Thirdly, the symphysial angle (the angle between the middle line of the symphysis and the vertical) rises during gestation, and then sinks after birth as the spout-like symphysis is achieved. In the youngest African foetus (text-fig. 8) this angle is about 70°; at half term it becomes about 50°; in the just-born elephant it is already beginning to sink, and is 55°; at six months it has fallen to about 65°; and in the adult it is at least 70°, with a recurved tip. This size of the symphysial angle is correlated with the curvature of the pre-alveolar region, which in the youngest African foetus has the largest deflection, but becomes less inclined up to birth. Subsequent to birth there is a marked change in this region, resulting in a second dropping of the symphysis with the formation of the scooped-out condition, in which the dorsal border descends steeply between the most anterior tooth and the almost horizontal symphysis.

Except for the tusk, therefore, the embryonic stages repeat the palæontological story. But the retrogressive changes which result in the shortening of the jaw, the tilting upwards and then the tilting downwards of the symphysis as the spout-like shape is achieved, involve a metamorphosis which we do not understand, and no material is available which could help us to do so. It is not easy to explain it by differential growth, and we have no evidence that the

bone, once formed, is absorbed, although this is suggested by a comparison of the just-born and six months' old stages (text-fig. 9). There are two reasons for this supposition. One is that the pre-alveolar region of E. 2 is actually shorter than that of E. 1, and the other that the part which shrinks is corroded, as if to imply that absorption is occurring. Experiments with madder, which might give us the evidence we require to prove it, are impossible in this case.

Text-figure 8.



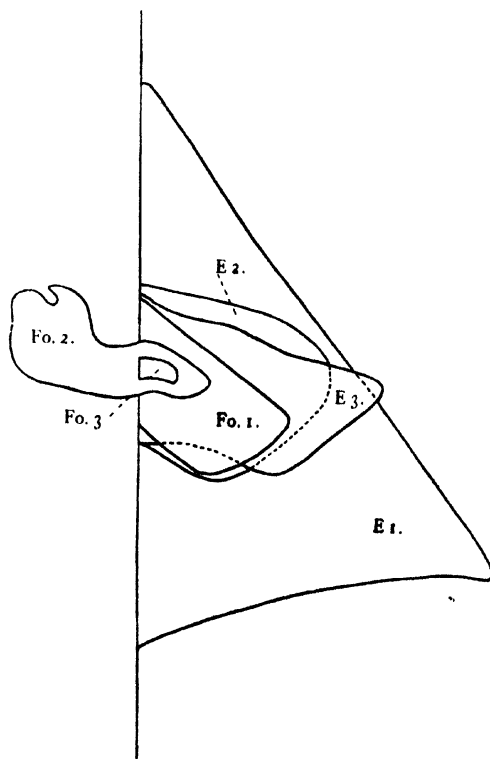
The pre-alveolar region of the right side of the six mandibles, drawn to the same scale as text-fig. 7, and shown in mesial view to give the position of the *symphysis menti* and the angle that it makes with the vertical line drawn through the first tooth. Note the decrease in the angle during gestation, and its increase as the adult condition is attained.

We are left only with the fact that the metamorphosis does occur, both in phylogeny and ontogeny.

The development of the elephant's jaw furnishes us with a beautiful example of the retention of an ancestral peculiarity. There can be no dispute about it, because the special peculiarity belongs to elephants alone. A deflected mandible with useless pre-alveolar region and overhanging upper jaw occurs in no extinct mammals other than the elephants, and in no modern adult

mammal*. But the *foetal* stages of the only two modern representatives of the elephants exhibit this unique feature. During the gestation period their

Text-figure 9.



The pre-alveolar region of the right side of the six mandibles in lateral view. The three foetal mandibles have been enlarged $1\frac{1}{2}$ times, the three post-natal stages are half natural size, the last three being too large to be drawn to the same scale as the foetuses. The mandibles have been spaced equally for convenience; the arrangement does not imply that growth occurs equally on all sides of the jaw. The figure shows the *actual* increase in size and deflection of the pre-alveolar region of the foetal mandible, and the subsequent upward and then downward tilt of this region post-natally. By comparison with text-fig. 8 it will be seen that the pre-alveolar region of E. 3, is both relatively and absolutely longer than that of E. 2.

jaws are of the *longirostrine* type, and resemble those of their extinct relations; then, during early post-natal development, the jaws shorten, and gradually become like those of their parents, *Elephas* or *Loxodonta*.

* There is some deflection of the mandible in the related *Sirenia*. But here the upper jaw is different; it curves parallel with the lower jaw, though it does not cover it as in the *Proboscidea*. Moreover, both jaws are functional anteriorly, the deflected portion of the mandible acting against the cropping-pad on the upper jaw.

LITERATURE.

- ANDREWS, C. W. — On the Evolution of the Proboscidea. Phil. Trans. Roy. Soc. Lond. vol. cxvii. B, 1903(04), pp. 99-118.
- ANDREWS, C. W. — A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt. London, British Museum, 1906. (Proboscidea, pp. 99-171.)
- BRITISH MUSEUM (NATURAL HISTORY). — A Guide to the Elephants (Recent and Fossil). Second edition. London, 1922.
- EALES, N. B. External Characters, Skin and Temporal Gland of a Fœtal African Elephant. Proc. Zool. Soc. Lond. part 2, 1925, pp. 445-456.
- EALES, N. B. The Anatomy of the Head of a Fœtal African Elephant, *Elephas africanus* (*Loxodonta africana*). Trans. Roy. Soc. Edin. vol. liv. pt. 3, no. 11, 1926, pp. 491-551.
- EALES, N. B. The Anatomy of a Fœtal African Elephant. Part 2. The Body Muscles. *Ibid.* vol. lv. pt. 3, no. 25, 1928, pp. 609-642. Part 3. The Contents of the Thorax and Abdomen and the Skeleton. *Ibid.* vol. lvi. pt. 1, no. 11, 1929, pp. 203-246.
- GAVER, F. VAN. — Étude ostéologique de la tête d'un jeune Éléphant d'Asie. Ann. Mus. hist. nat. Marseille, tom. 20, 1925, pp. 5-93.
- GRAY, J. E. Notes on the Fœtus of an Elephant and a Hippopotamus in the Collection of the British Museum. Proc. Zool. Soc. Lond. 1868, p. 491.
- GREGORY, W. K. — Adaptive Significance of the Shortening of the Elephant's Skull. Bull. Amer. Mus. Nat. Hist. vol. xix. 1903, pp. 387-394.
- GREGORY, W. K. The Orders of Mammals. Bull. Amer. Mus. Nat. Hist. vol. xxvii. 1910, pp. 1-524.
- OSBORN, H. F. Final Conclusions on the Evolution, Phylogeny, and Classification of the Proboscidea. Proc. Amer. Phil. Soc. Philad. vol. lxiv. no. 1, 1925, pp. 17-35; and other papers on fossil Proboscidea.
- TOLDT, K., Jun. Ueber die aussere Korpergestalt eines Fetus von *Elephas maximus*. Anz. Akad. Wiss. Wien, Jg. 50, 1913, p. 302.
- WEBER, M. — Die Säugethiere. G. Fischer, Jena. Second edition, 2 vols., 1927 and 1928.

EXPLANATION OF THE PLATE.

PLATE I.

- (a) Fœtus of African Elephant, *Loxodonta africana*. From a photograph. The fœtus is shown curled up as it lay within the uterus. Its age is probably about ten months, or rather less than half term. $\times \frac{7}{8}$.
- (b) Fœtus of African Elephant belonging to the Natural History Museum. It is less than half the size of Fo. 1, and its age is unknown. The proboscis has been broken off. $\times 1$.
- (c) Fœtus of Indian Elephant, *Elephas maximus*, belonging to the Natural History Museum. It is about two-thirds the size of Fo. 2, and its age is not known. The proboscis has been broken off at the base. $\times 1\frac{1}{2}$.

Reference Letters to the Text-figures.

| | | | |
|--------|-----------------------------------|---------|--------------------------|
| c.M. | Meckel's cartilage. | Fo. 1. | Older African fœtus. |
| con.m. | Mandibular condyle. | Fo. 2. | Younger African fœtus. |
| DP. 2. | First deciduous premolar tooth. | Fo. 3. | Indian fœtus. |
| DP. 3. | Second deciduous premolar tooth. | f.i.d. | Inferior dental foramen. |
| DP. 4. | Third deciduous premolar tooth. | f.m. | Mental foramen. |
| E. 1. | Adult African elephant. | pr.cor. | Coronoid process. |
| E. 2. | African elephant, six months old. | s.m. | Symphysis menti. |
| E. 3. | Just-born African elephant. | | |

10. On the Larva of the Poisonous Chrysomelid Beetle of N'gamiland,
Africa. By S. MAULIK, M.A., F.Z.S.

[Received August 25, 1930 · Read February 3, 1931.]

(Text-figures 1-5.)

MATERIAL AND METHOD.

In the collection of larvæ of Chrysomelid beetles of the British Museum I have found three specimens and three cocoons with a label which contains the following particulars:—"Larvæ of phytophagous beetle *Diamphidia*, said to afford Bushmen poison for arrow, N'gamiland, 2. xii. 1898, presented by Captain E. T. Lugard, D.S.O." The following notes have been made from this material. Probably this insect is *Cladocera nigrovittata* Stål. There is one example in the collection of the British Museum of this species from N'gamiland, but the larvæ may belong to another species.

The larvæ were cleared in potash and then put in acetic acid. While in the acid the sclerites become clearly defined, and their position and relationship with each other can be recognized without difficulty. These cleared larvæ are preserved in 70 per cent. alcohol, and can always be studied in the floating condition under a binocular. For the study of minute structures microscopic preparations were made, and these have been permanently mounted in balsam.

In 1928 Mr. P. A. Buxton sent to the British Museum some beetles which he had received from the Kalahari Desert for identification. I identified these as *Cladocera nigrovittata* Stål. The larvæ of these are also said to supply the Bushmen with arrow-poison. Preparations from this material have also been made for purposes of comparison with the original British Museum examples.

Body. (Text-fig. 1.)

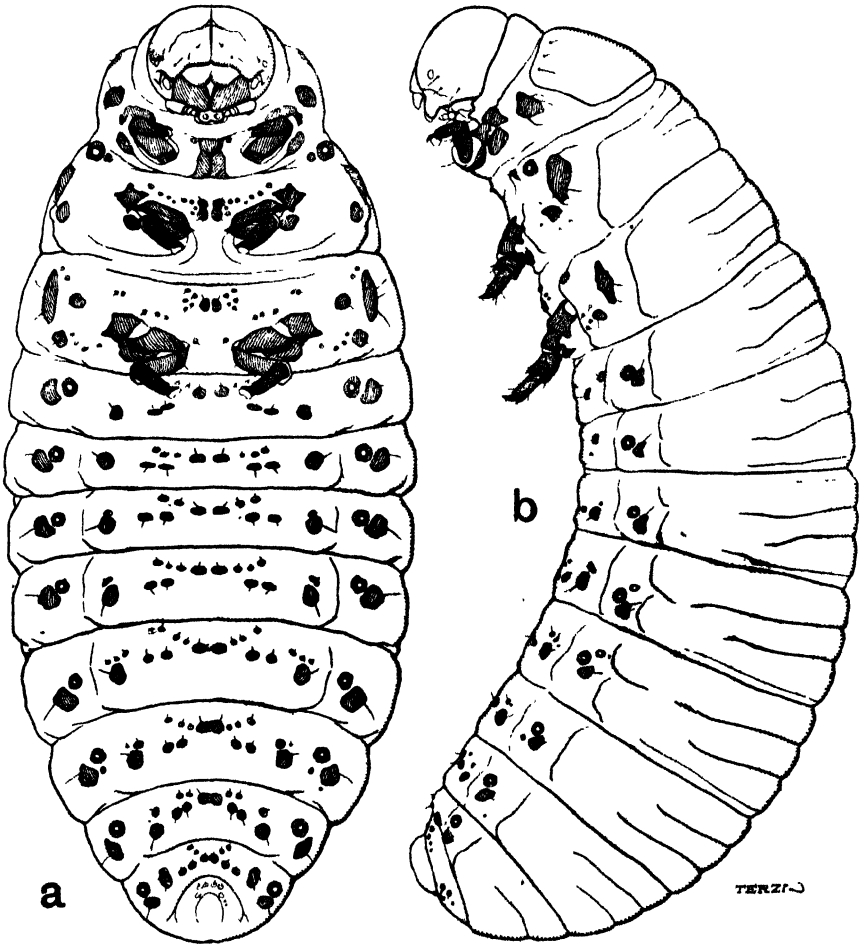
Measurements. Uncleared specimen: length 10 mm., width 5 mm.; after treatment with potash, length 14 mm., width $6\frac{1}{2}$ mm. Imago: length 9-11 mm., width 6-7 mm.

The general colour is creamy white with a pale pink tint. The chitinated parts, including the head with the mouth-parts, the legs, the spiracular openings, and the spots and patches, are black or dark brown—the stronger the chitination the deeper the colour.

The body is narrowed anteriorly and less so posteriorly. It is convex dorsally, sloping down gradually in front and more abruptly behind. The larva consists of thirteen segments, including the head, three thoracic segments, and nine abdominal segments. Each of the first eight abdominal segments bears a pair of spiracles, one on each side lying more ventrally than laterally. There is only one pair of thoracic spiracles, one on each side almost ventrally, and anteriorly on the mesothorax. Therefore there are, altogether, nine pairs of spiracles. The opening of a spiracle is circular. The dorsal surface of the larva is without any chitinated patches or spots, but on the ventral surface there are several series of them (see text-fig. 1).

In two similarly-cleared larvæ the ventral spots and patches are hardly developed. It is possible these two larvæ may belong to a different species, but I think they belong to the species under consideration, *i. e.*, *Cladocera nigrovittata* Stål. It must be remembered that resemblance of larval structures does not necessarily indicate resemblance in the imagos; on the other hand, dissimilar larvæ may produce similar imagos.

Text-figure 1.

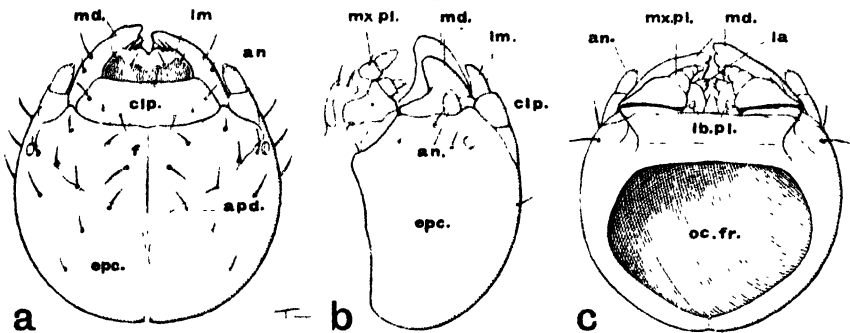


Cladocera nigrovittata Stål, larva; a, ventral view; b, lateral view.

The arrangement of the ventral patches and spots is as follows :—Between the prothoracic legs there is a large chitinised patch with a longitudinal median suture. Between the mesothoracic legs, but situated a little anteriorly, there is a group of spots of which two are large, having the smaller ones arranged on each side. On the metathorax there is a similar group, consisting of two larger median patches flanked by smaller spots which are less numerous than those on the mesothorax. On each abdominal segment the group consists of two

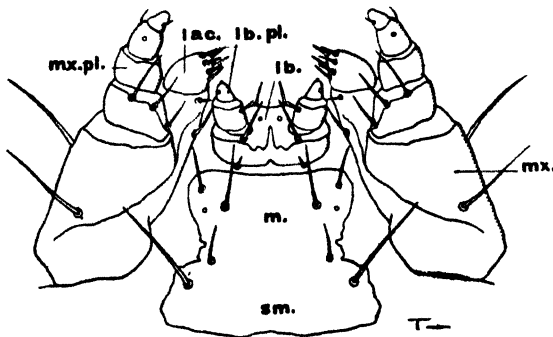
large median patches with four or five smaller ones on each side. These are not placed so close to each other as those on the thoracic segments. The median larger patches become more closely approximated, and the other smaller spots of the group become somewhat larger as the apical segment of the abdomen is approached. Between this median longitudinal group-series and the row of spiracles there is a row of patches, generally one on each abdominal segment, but there may be two or three additional smaller ones. On the anal segment the spots are much smaller. On the outer side of each spiracle is a large patch. In continuation of the spiracular row the thoracic segments possess much larger lateral patches, three on the metathorax, two on the mesothorax, and one, somewhat smaller, on the prothorax. The spots and patches are strongly-chitinised sclerites, each having a small seta.

Text-figure 2.



Head of larva: a, dorsal view; b, lateral view; c, ventral view.

Text-figure 3.



Mouth-parts of larva, from below.

md. Mandible. lm. Labrum. an. Antenna. mx. Maxilla. mx.pl. Maxillary palpus. ctp. Clypeus. lac. Lacinia. lb.pl. Labial palpi. f. Front. epc. Epicranium. apd. Strongly chitinised base of the apodeme forming the internal skeleton of the head. oc.fr. Occipital foramen. m. Mento. sm. Submentum.

HEAD. (Text-fig. 2.)

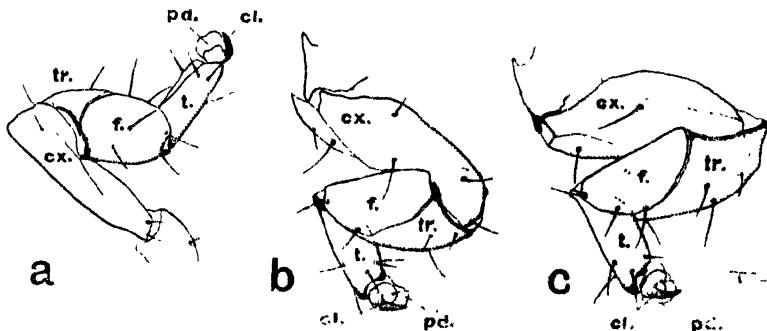
The head-capsule is well formed, strongly convex above, with a median suture bifurcating at about the middle. Thus the head is divided dorsally

into the two epicranial halves and the front. The clypeus is about four times as broad as long, and not so strongly chitinised as the head-capsule. The labrum, situated ventrally to the clypeus, is much narrower and deeply emarginate in the middle. Ventral to the labrum are hinged the two heavily-chitinised mandibles, the cutting-edge of each being somewhat concave, and at the apex provided with three broad "teeth." External to the base of a mandible, and close to the anterior edge of the front, is placed an antenna, which appears to consist of one segment with its apex studded with several minute sensory papillæ, and with a wider but less-chitinised base. The central largest papilla, round which the smaller ones are arranged, may be regarded as a second segment of the antenna. There are no ocelli in specimens under examination. The ventral mouth-parts, consisting of submentum, mentum, labium, and maxillæ, are clearly seen in text-fig. 3. The labial palpus has two segments and the maxillary three.

LEGS. (Text-fig. 4.)

The legs are well developed. Each consists of a trochanter femur, tibia, claw, and a pad attached to the apex of the tibia. The trochanter is large

Text-figure 4.



Legs of larva. a, front legs; b, middle leg; c, hind leg.

cl. Claw. pd. Pad under claw. t. Tibia. f. Femur. tr. Trochanter. cx. Coxa.

and less chitinised than the femur or tibia. The femur is strongly chitinised dorsally, but very weakly so ventrally. The tibia is similar in structure, and is produced to a blunt knob at the point of its articulation with the femur.

COCOON. (Text-fig. 5.)

The larva is enclosed in a cocoon which is constructed of small bits of gravel and sand fastened together by some sort of cement. The cocoon is oval in shape, which is fairly constant, neat in construction, and has, in some cases at least, one end slightly broader than the other. The length varies from 11 to 13 mm., and the width from 8 to 9. The crust forming the cocoon is very thin and very easily breakable. The larva lies doubled up in the cocoon; that is to say, the anterior and posterior ends almost touch each other. The larva lives long in the cocoon without changing into a pupa. One of

the cocoons that were sent from Kalahari in 1928 was opened in June 1930 ; the larva was alive and healthy. When taken out of the cocoon it rapidly degenerates and dies.

Text-figure 5.



Cocoon showing the round opening on top.

SUMMARY.

- (1) The larva has well-developed spots and patches on the ventral surface only.
- (2) The head is well developed, without ocelli, and with normal mouth-parts.
- (3) The legs are well developed ; the tibia is produced into a blunt knob at the point of its articulation with the femur.
- (4) The tibia has at its apex a pad-like structure and a strong claw.
- (5) A neat oval cocoon is formed of little bits of gravel in which the larva pupates.
- (6) The larva is able to live in the cocoon for a considerable period of time without turning into a pupa.
- (7) Outside the cocoon the larva rapidly degenerates and dies.

11. A Contribution to the Biology of the Common Shrew, *Sorex araneus* Linnæus. By A. D. MIDDLETON.

(From the Department of Zoology and Comparative Anatomy, University Museum, Oxford.)

[Received June 11, 1930: Read February 3, 1931.]

(Text-figures 1-4.)

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1. INTRODUCTION.

The subject-matter of this paper was obtained in the course of a routine trapping and examination of Common Shrews (*Sorex araneus* Linnæus) and Pigmy Shrews (*Sorex minutus* Linnæus) from the Oxford district between February 1926 and August 1927. The work was carried out as a side-line of a team research, financed by the Medical Research Council, into the ecology of wild mice and voles, so that many of the most interesting points have had to be neglected, and some of the matter incorporated is rather fragmentary. I wish to acknowledge the co-operation of Mr. C. S. Elton, Dr. J. R. Baker, and Mr. E. B. Ford, by whom much of the work, especially trapping, was done in the course of the general research on mice and voles.

I also wish to thank Professor E. S. Goodrich, F.R.S., for allowing me the facilities of the Department of Zoology and Comparative Anatomy at Oxford.

2. TRAPPING AND METHODS.

All the shrews examined were caught in the ordinary course of trapping for wood-mice (*Apodemus sylvaticus*) in Bagley Wood, and in trapping field-voles (*Microtus hirtus*) on rough grass areas in the district. No trapping was done with the sole intention of catching shrews, and, as most of the traps used were incapable of retaining shrews, the numbers caught were much less than would have been the case if purposeful trapping had been carried out. The baits used were also chosen for their suitability for mice and voles, and as shrews are insectivorous, vegetable baits would have little attraction for them. It

is probable that such shrews as were caught merely went into the traps in the course of their extensive wanderings in search of food. Some were caught in break-back traps set in the underground and surface-runs of *Microtus*, but most were caught in Tring traps, particularly effective traps for catching mice alive, and from which shrews rarely escaped. Although the traps were visited frequently, often three times in the course of 24 hours, very few were obtained alive, as they appeared to die quickly from shock or exposure when caught in traps. When visiting the traps, each shrew was shaken out of the trap into a linen bag and taken back to the laboratory for examination. The bodies were weighed to the nearest gram, and the body- and tail-lengths recorded in millimetres. The reproductive organs were then examined by a routine method to be described later. Examinations were also made for external and internal parasites, the results of which are being published elsewhere.

3. HABITATS.

Shrews were caught in considerable numbers in each of the following types of plant associations :—

- Conifer woods with little or no undergrowth.
- Open rough grass land.
- Borders of thick woods, with grass, bracken, etc.
- Open coniferous woods with undergrowth of brambles, etc.
- Mixed deciduous woods.
- Young plantations, with grass, bracken, etc.
- Open grassy areas in woods, with brambles, etc.

Owing to the fact that trapping was carried out solely with the object of catching mice and voles, the numbers of shrews caught in the different habitats do not in any way indicate the most favourable conditions for shrews. The impression gained during trapping was that the most favoured habitats were rough grassy dykes, with plenty of scrub, brambles, etc., and the edges of thick woods.

4. FOOD AND HABITS.

The contents of the stomach and intestines were usually an indistinguishable mass when the shrews were examined, but setæ of earthworms (genus and species not identified) were found in the stomach and intestines of some. On several occasions mice which had died in the traps were found partly eaten, presumably by shrews, as these small mammals could enter the traps through the bars in such cases. On one occasion two live shrews were placed in a cage together : one had killed and almost entirely eaten the other by the following day.

Unlike mice and voles, it appears that shrews show no well-defined reaction to light and darkness, being trapped with equal facility during both day and night. As the shrew undoubtedly hunts for its food almost entirely by its keen sense of smell and touch, and the worms and insects on which it feeds can be found equally well in daylight and darkness, there is no necessity for a long period of inactivity. The high rate of metabolism of such a very small mammal also makes frequent feeding a necessity. As far as could be ascertained, shrews do not make run-systems of their own, but make common use of the runs of mice and voles. They were frequently caught in the underground and surface-runs of *Microtus*, and on one occasion a *Microtus*, an *Apodemus*, and

a shrew were caught in three successive days in the same trap set in an underground *Microtus* runway on a rough grass area. They also appear to use the runways of the mole (*Talpa europæa*), as many large mole-fleas (*Hystri-chopsylla talpæ*) were found on shrews on various occasions.

Numerous skulls and bones of shrews were found in the castings of owls from Bagley Wood. Several records are available of shrews being eaten by the Brown Owl (*Syrnium aluco*)*. The Brown Owl is probably the principal enemy of the shrew.

5. SEX-RATIO.

The sex-ratio of all the shrews examined was 160 males to 100 females. An exceptionally high sex-ratio seems to prevail among all the age-groups, though greater in the old than in the young. In Table I. the sex-ratios of three weight-groups are given. It is possible that the methods employed in trapping made it more likely that males would be caught owing to their greater general activity, and the data are very scanty for the purpose of working out a sex-ratio, so that a large margin of error must be allowed on these figures.

TABLE I.—The Sex-ratio in different Weight-groups of *Sorex araneus*.

| Weight | 5-7 grms. | 8-10 grms. | 11-15 grms. | All weights. |
|---------|-----------|------------|-------------|--------------|
| Males | 76 | 82 | 33 | 191 |
| Females | 56 | 42 | 21 | 119 |
| Ratio | 136 | 195 | 156 | 160 |

6. REPRODUCTION.

Technique.

In males the weight of the two testes together, freed from epididymes and connective tissues, was recorded in milligrams. If the weight was over 100 milligrams weighing was carried out to the nearest 5 milligrams only. The contents of the epididymes were then examined for sperms. After the microscopic examination of 67 epididymes it was found that any shrew with testes weighing 200 milligrams or more could be classed as fecund, without examination of the epididymes, and this method was therefore adopted in preference to the somewhat tedious microscopical examination. In practice little difficulty was experienced on this point, as the testes weights generally fell into two distinct groups—very small in the immature animals, and very large in the mature males. Any doubtful sizes were usually confirmed microscopically.

In the females it was noted whether the animal was or was not pregnant, and, if pregnant, the number and weight of the embryos were recorded. The weight of embryos in pregnant females, if amounting to one or more grams, was deducted from the total weight for the purpose of recording the body-weight.

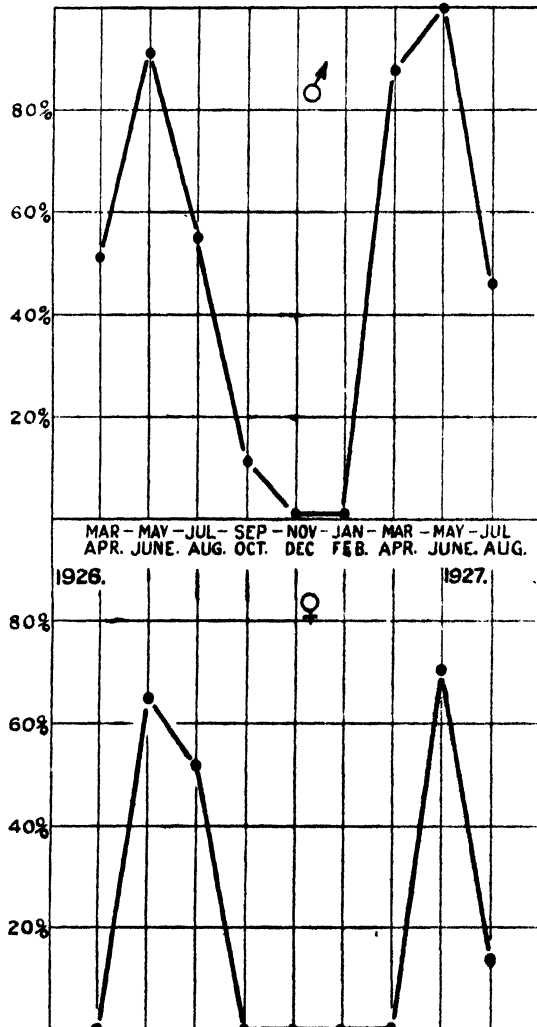
A body-weight of 8 grams or more has been adopted as signifying an adult shrew, as this was the smallest weight at which males were found to be fecund or females to be pregnant; but, as will be shown later, the term "adult" defined in this manner is not synonymous with "sexually mature"—at any rate for males.

* F. Pitt, 'The Naturalist,' 1918, p. 267; Yarrell's 'British Birds' (Newton) i. p. 148.

Results.

In text-fig. 1 (top) the percentage of adult males which were fecund is shown for bi-monthly periods from March 1926 to August 1927. It will be

Text-figure 1.



Sorex araneus. (Top) The percentage of adult males fecund, and (bottom) percentage adult females pregnant, from March 1926 to August 1927.

seen that the fecundity is greatest in May and June, and thereafter declines rapidly, no fecund males being found in the late autumn and winter months. The data from which this graph is drawn are given in Table II.

TABLE II.—Data on Reproductive Activity of Male *Sorex araneus*.
March 1926 to August 1927.

| Period. | Total examined. | Adults. | Fecund. | Per cent. adults fecund. |
|---------------------|--------------------|---------|---------|-----------------------------|
| Mar.-April | 14 | 13 | 7 | 54 |
| May-June | 23 | 13 | 12 | 92 |
| July-Aug. | 30 | 20 | 11 | 55 |
| Sept.-Oct. | 38 | 20 | 2 | 10 |
| Nov.-Dec. | 30 | 5 | 0 | 0 |
| Jan.-Feb. | 5 | 0 | 0 | 0 |
| Mar.-April | 26 | 25 | 22 | 88 |
| May-June | 15 | 12 | 12 | 100 |
| July-Aug. | 11 | 8 | 4 | 50 |

TABLE III.—Data on Reproductive Activity of Female *Sorex araneus*.
March 1926 to August 1927.

| Period. | Total examined. | Adults. | Pregnant. | Per cent. adults pregnant. |
|---------------------|--------------------|---------|-----------|-------------------------------|
| Mar.-April | 7 | 4 | 0 | 0 |
| May-June | 12 | 11 | 7 | 64 |
| July-Aug. | 15 | 8 | 4 | 50 |
| Sept.-Oct. | 23 | 9 | 0 | 0 |
| Nov.-Dec. | 18 | 3 | 0 | 0 |
| Jan.-Feb. | 6 | 0 | 0 | 0 |
| Mar.-April | 11 | 6 | 0 | 0 |
| May-June | 18 | 14 | 10 | 72 |
| July-Aug. | 9 | 8 | 1 | 13 |

TABLE IV.—Data on Pregnant Female *Sorex araneus*.
1926 and 1927 combined.

| Month. | Adult females. | Pregnant females. | No. of embryos. | Embryos per 100 adult females. | Average litter- size. |
|------------|-------------------|----------------------|--------------------|--------------------------------------|-----------------------------|
| May | 15 | 11 | 82 | 547 | 7.4 |
| June | 10 | 6 | 41 | 410 | 6.8 |
| July | 13 | 4 | 24 | 185 | 6.0 |

TABLE V.—Numbers of Embryos in Pregnant Female *Sorex araneus*.

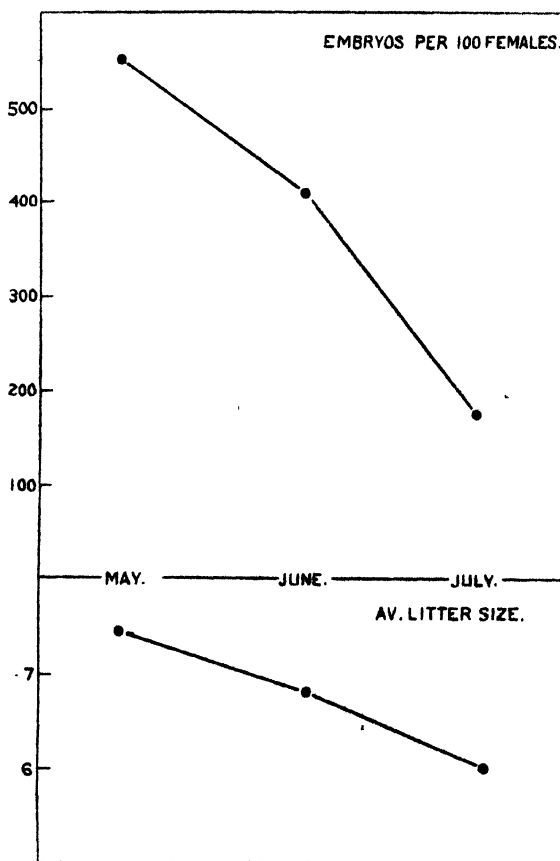
| 1926. | | | 1927. | | |
|---------------|-----------------------------------|--------------------|---------------|-----------------------------------|--------------------|
| Date. | Body-weight (without embryos). | No. of embryos. | Date. | Body-weight (without embryos). | No. of embryos. |
| May 7 . . . | 11 | 7 | May 10 | 11 | 7 |
| May 10 | 11 | 7 | May 11 | 10 | 6 |
| May 11 .. . | 9 | 8 | May 12 | 13 | 9 |
| May 15 | 9 | 8 | May 14 | 15 | 9 |
| May 15 | 9 | 6 | May 19 | 11 | 8 |
| June 14 . . . | 10 | 8 | May 21 | 11 | 7 |
| June 15 | 12 | 7 | June 7 | 12 | 6 |
| July 5 | 11 | 6 | June 14 | 9 | 10 |
| July 10 | 10 | 6 | June 18 | 11 | 4 |
| July 15 | 13 | 7 | June 22 . . . | 10 | 6 |
| Aug. 8 | 9 | 5 | July 16 . . . | 14 | 5 |

TABLE VI.—Numbers of Fecund and Non-fecund Male *Sorex araneus* in three quarters of 1926.

| Period. | Total adults. | Fecund. | Non-fecund. |
|------------|---------------|---------|-------------|
| March-May | 24 | 18 | 6 |
| June-Aug. | 22 | 12 | 10 |
| Sept.-Nov. | 23 | 2 | 21 |

In the same figure (bottom) a graph is given of the percentage of adult females found pregnant during the same period. The period during which females were found to be pregnant is very short, there being no breeding after

Text-figure 2.



Sorex araneus. The production of embryos per 100 adult females, and the average litter size, for the months May, June, and July (1926 and 1927 combined).

August. It may be stated that the autumn of 1926 in the Oxford district was exceptionally mild and open, so that this short breeding-season was not due to unusually severe climatic conditions. Table III. gives the data on which this graph is based.

In text-fig. 2 the productive power of the females is shown graphically as the number of embryos per 100 adult females produced during the three months May–July, the data for 1926 and 1927 combined. The remarkable drop in production in July may be partly due to the inclusion of young adults in the number of non-pregnant females. Table IV. gives the data from which this graph is obtained.

In the same figure the average litter-sizes for May, June, and July are shown (combined data for 1926 and 1927).

In Table V. the data on the number of embryos in each of the pregnant females examined are given for both 1926 and 1927. From this it will be seen that the litter-size averages about 7–8 at the height of the breeding-season.

Discussion.

In Table VI. the actual numbers of male shrews of 8 grams weight and over examined during three three-monthly periods in 1926 are given. It will be seen that in the period March–May most of these adults were fecund, and the few that were not had probably not had time to become fecund before examination. The period June–August also shows a large number fecund, and the non-fecund animals of this period will be the young of the same year. From September to November practically no fecund males were found, but a large number of non-fecund adults. It would appear from this, in conjunction with the fecundity graph in text-fig. 1, that the males born in 1926 did not become fecund in that year, and the reduction in numbers of fecund males during the summer was due to the dying-off of the old males which had lived over the preceding winter. If the young males became fecund in the year of their birth it is almost certain that there would have been a high percentage of fecund males in the late summer and early autumn.

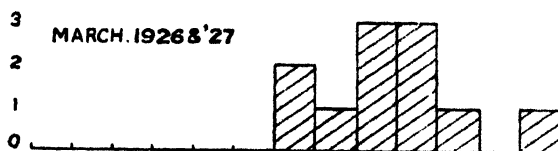
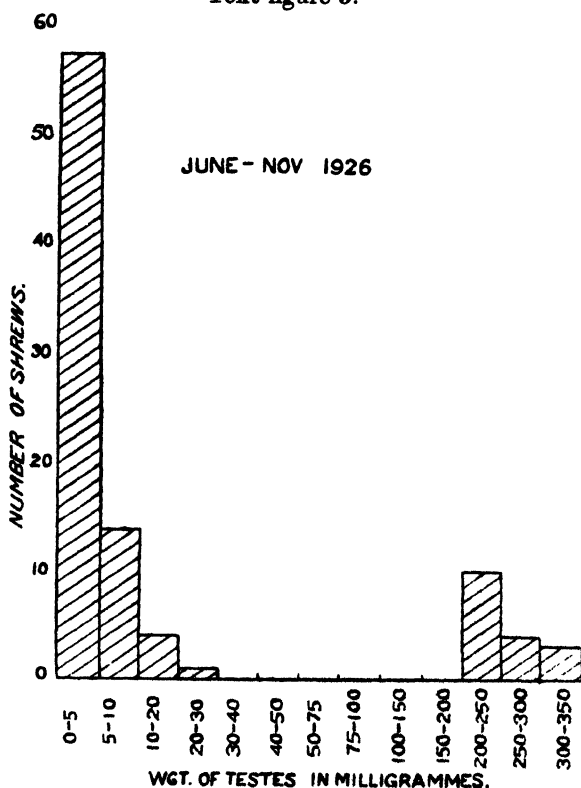
Further evidence in support of this view is given by an analysis of the testes-weight records during the period of 1926 when the young males were growing up. In text-fig. 3 the frequency of different sizes of testes during the period June–November 1926 is shown in the form of a diagram. It will be seen that testes fall into two sharply-defined groups: the very small obviously non-fecund, and the large fecund over 200 milligrams. Not a single case is recorded between 30 milligrams and 200 milligrams. If the young males born during the early summer had been developing their testes to maturity during this period, it is practically certain that a number of shrews would have been found with testes of varying weights between 30 and 200 milligrams.

At the bottom of text-fig. 3 the frequency of testes sizes for March only (1926 and 1927 combined) is similarly plotted to show that at this period, when development of the testes of the old males was taking place, intermediate sizes were frequent.

An examination of the reproduction data of the females shows a remarkable drop in the production of young after the first outburst in May and June. As shown in text-fig. 2, both the number of embryos per 100 adult females and the average litter-size are lower during June and July than in May—the month when the old females produce their first young. Now, if the females born during May and June reached sexual maturity and became pregnant in the same year, a considerable number of pregnant females would be found during August and September. The graph in text-fig. 1 is plotted in bi-monthly periods, and the percentage of the adult females in the period July–August shown as pregnant is mainly due to the July figures, as only one pregnant female was found in August 1926, and none at all in August 1927. The supposition that these later pregnancies were the later litters of the old females would account for the

fall in the percentage and in the litter-size. The male data show that there were sufficient fecund males to fertilize young females during July and August.

Text-figure 3.



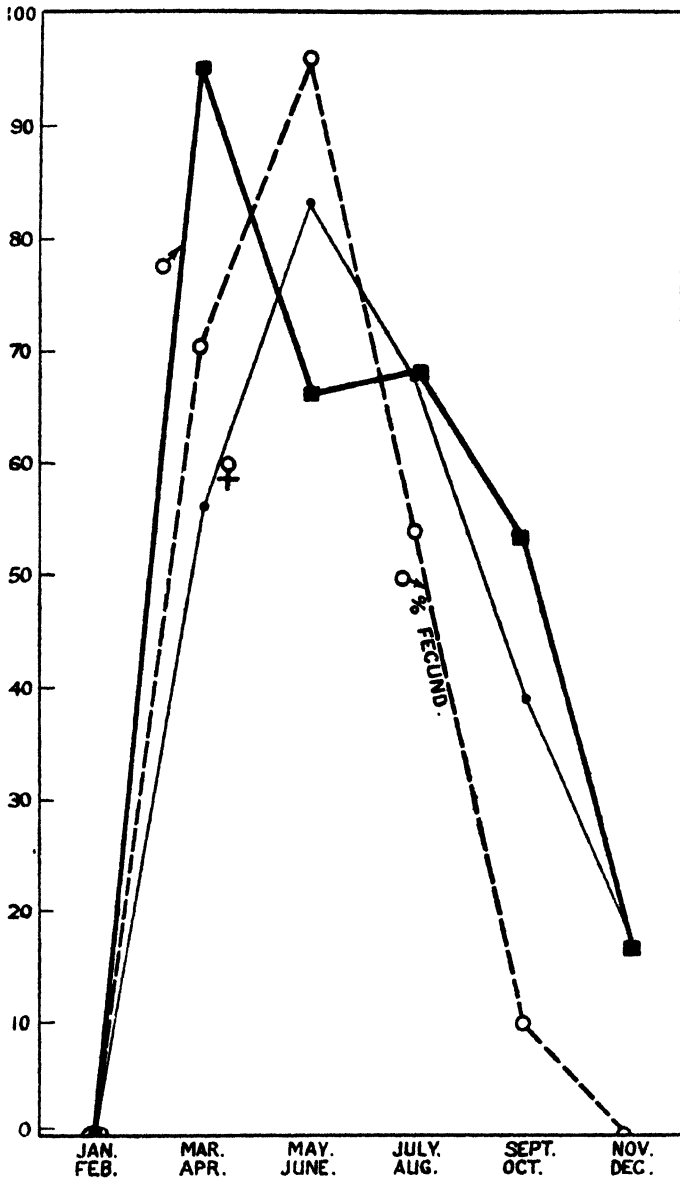
Sorex araneus. The frequency of testes sizes in all males during late summer and autumn of 1926, and during March (1926 and 1927 combined).

so that it appears probable that the females also do not become sexually mature in the year of their birth. Such a position would be quite reasonable if the onset of the oestrous cycle were delayed until the spring.

7. AGE DISTRIBUTION IN THE POPULATION.

The percentage of the population represented by large shrews (those weighing 8 grams or more) varies considerably at different times of the year. In text-fig. 4 the variation in the percentage of these "large" shrews in the population is plotted in bi-monthly periods over the year. The thick black line shows

Text-figure 4.



Sorex araneus. The variation in the percentage of the population represented by large shrews (8 grams weight or over) in bi-monthly periods throughout the year. Males and females plotted separately, and graph of the percentage of males fecund superimposed as a dotted line.

the percentage of large males in the total male population, while the thin line shows the corresponding percentage for the females. The data from which these curves are constructed will be found in Tables II. and III.

It will be seen that no large shrews of either sex were found in the period January–February, and as no breeding takes place after August, the main population of small shrews during this period cannot be called young. A sudden and pronounced increase in size takes place in the spring months, and the majority of the population consists of large shrews from March to August. During the period from July onwards a large number (probably the majority) of these large shrews will be those born in May and June. During the next two periods, September to December, a remarkable drop in the percentage of large shrews occurs, to reach the final winter stage of January–February, when practically no shrews are found in the “large” class. It seems obvious from these figures that a definite loss of weight occurs among all shrews in the autumn, and that the winter size is much smaller than that reached by the young animals during the late summer months. The spring increase in size corresponds with the attainment of sexual maturity.

The graph of the percentage of adult males fecund (text-fig. 1) is superimposed on this graph as a dotted line, to give further proof of the view already expressed that the male shrews do not become fecund in the year of their birth. The rapid fall of the percentage fecund after June, while the majority of the males are above the size at which sexual maturity is possible, indicates that the majority of these full-sized males, in the period from July onwards, cannot have reached the sexual maturity which they should have done if sexual development was synchronous with increase in size.

The whole of these facts, taken in conjunction with the data on reproduction, appear to indicate that the young born in the early summer reach a certain stage of growth, without becoming sexually mature, by the autumn, when a decrease in size occurs which is maintained throughout the winter. In the following spring an increase is accompanied by sexual maturity, and breeding commences. After the short but prolific breeding-season the old shrews gradually die out, so that none are left by the following winter.

8. MEASUREMENTS.

The average measurements taken from 40 shrews all of 8 grams’ weight were:—Length of body, 72 mm.; length of tail, 39 mm.; length from tip of nose to tip of tail, 111 mm.

The smallest shrews caught weighed 5 grams, and the largest 15 grams.

9. THE PIGMY SHREW (*Sorex minutus* Linnaeus).

28 Pigmy Shrews were examined in the course of the work: 16 males and 12 females. These were caught in similar habitats and conditions to the Common Shrew. The usual body-weight of the sexually mature animals was 4 grams; only two were caught which weighed as much as 5 grams, while 3 grams was a common winter weight.

14 fecund males were examined from April to June, and the average weight of the testes of these was 150 milligrams. Only three pregnant females were examined, of which the details are as follows:—

| Date. | Weight. | No. of Embryos. |
|------------------|---------|-----------------|
| May 7, 1926..... | 4 grms. | 8 |
| 11, “ | 4 “ | 8 |
| 21, “ | 5 “ | 6 |

Of 15 Pigmy Shrews, all weighing 4 grams, the average length of the body from the tip of the nose to the anus was 52 mm., of the tail 37 mm., and total length 89 mm.

The number of Pigmy Shrews caught is probably in no way indicative of the relative numbers in the district as compared with the Common Shrew, as most of the traps used would make the escape of such very small mammals an easy matter.

10. SUMMARY.

Trapping and routine examinations carried out in the Oxford district between February 1926 and August 1927, show that :

1. *Sorex araneus* is found in a wide range of habitats, varying from pure grass-land to dense conifer woods.

2. The breeding-season is from May to August, and no pregnant females are found outside this period. It is uncertain whether the females have more than one litter during a breeding-season.

3. It is suggested from the evidence available that neither male nor female shrews become sexually mature and breed during the year of their birth.

4. It appears that the young shrews reach a certain immature stage of growth by the late autumn of the year of their birth, and remain in that condition throughout the winter months. In the spring a marked increase in size takes place, and sexual maturity is reached.

12. Contributions to our Knowledge of the Duration of Life in Vertebrate Animals.—V. Mammals *. By Major STANLEY S. FLOWER, O.B.E., F.L.S., F.Z.S.

Received November 18, 1930 · Read March 3, 1931.]

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1. PREFACE.

No general account of the age to which mammals live appears to have been published.

This paper is a summary of notes collected during the past thirty-two years; it is only a contribution to knowledge and not, in any way, a final conclusion.

One fact brought out by these enquiries is not without general interest, that is, that the life-spans of domestic animals such as the Cat, Dog, and Horse have not been increased or decreased by the untold thousands of years that they have been under human control. Their lives are of the same length as would be expected from that of their wild "unimproved" relations.

The potential longevity of mammals differs from that of birds, reptiles, amphibians, and fishes in that, in the large majority of species, there is an additional controlling factor—the teeth.

The teeth of a mammal, according to its species, take a definite time to grow, and a less definite but still certain time to wear away, fall out or become functionless. When the teeth of a mammal, in its wild free state, become useless for procuring or biting food, the end of the animal must be death from starvation, unless it falls a victim to some other animal first or meets its death by some other accident occasioned by its enfeebled condition.

Thus the potential length of life of most existing mammals appears to be dependent, with certain important exceptions, on the duration of teeth.

* N.B. Previous contributions published in P. Z. S. :—

| | |
|-----------------------|----------------------------|
| I. Fishes..... | 1925, pp. 247-268. |
| II. Batrachians | " " 269-289. |
| III. Reptiles | " " 911-981. |
| IV. Birds | " " 1365-1422 [Jan. 1926]. |

These exceptions may be arranged in four sections :—

1. Those mammals in which the tongue is modified specially to act as an organ either to procure food or to force food, already in the mouth, into the throat. This section includes the Anteaters of the genera *Orycteropus*, *Manis*, *Myrmecophaga*, *Tarsipes*, and *Tachyglossus*, all the Whale-bone Whales, and certain Bats.
2. Those mammals in which the prey is procured by the jaws, regardless of teeth, and is swallowed whole, as in some genera of Whales.
3. Those mammals with persistently growing teeth, as the Water-Vole (M. A. C. Hinton, 1926, p. 18).
4. In the Duck-billed Platypus, *Ornithorhynchus anatinus*, the functions of teeth appear to be performed by the horny plates of the bill.

There is no criterion yet known by which to ascertain the exact age of any full-grown wild mammal. With domestic animals, for selling purposes, the varied means for making a beast appear younger than it really is has, in the course of centuries, become almost a "fine art."

The fact remains that though an expert may assign an approximate age to a mammal, other experts may disagree, and all that can actually be stated is that the animal is "aged," "old," or "very old."

Thus the only certain way in which the duration of life of mammals can be ascertained is by keeping individuals in captivity, and keeping a careful record of all dates concerning those individuals.

Herein lies one of the difficulties attending this enquiry : frequently an animal's longevity only begins to be noted when it is *known* to have lived for an unusually long time, and its birth-date has already become a subject of conjecture. Conjecture is at first considered as conjecture, but in process of time crystallizes itself into what the public mind believes to be real record. And although the vendor of an old Horse may like to pass it off as a young one, the reverse happens when such an animal as an Elephant is exhibited—the visitors want it to be very old, and the keepers are not backward in providing stories of its venerable antiquity.

Pari passu with the enquiries concerning longevity, information about the gestation periods of mammals has been collected : there appears to be no relation or correlation between periods of gestation and either specific or potential duration of life.

The classification and nomenclature used in this paper are according to the Society's Centenary Edition of the List of Animals exhibited in the Gardens, 1828–1927, vol. i, Mammals, published in 1929.

2. ACKNOWLEDGMENTS.

This paper could not have been compiled without the kind assistance of many friends in many countries, and the most important part of it—the data about the animals in the London Zoological Gardens—is due to Sir Peter Chalmers Mitchell, C.B.E., F.R.S., having given me every facility and encouragement to examine, and re-examine, the manuscript records in the possession of the Society. My grateful thanks are due to Sir Peter Mitchell, Dr. G. M. Ververs, Mr. D. Seth-Smith, Mr. F. Martin Duncan, and every official of the Society that I have met during the course of this work.

Dr. B. B. Ferrar, of the Royal Zoological Society of Ireland, has not only encouraged me to keep going on at this subject, but has always been ready to look up and give me information from the archives of the Dublin Zoological Garden.

The Edinburgh Zoological Garden is a comparatively young menagerie, but such information as is available has been freely given me by Mr. T. H. Gillespie.

Thanks to the late Mr. E. W. B. Villiers, to Mr. H. Reginald Woodward, to the late Mr. Richard Jennison, and to Mr. George Jennison, much knowledge of animals has been acquired from the Zoological Gardens of Clifton and Manchester.

I am also indebted for notes and advice to my sister, Mrs. S. P. T. Prideaux, to the late Mr. J. L. Bonhote, to Mr. A. L. Butler, to Mr. N. B. Kinnear, to the late Mr. R. Lydekker, F.R.S., to the late Mr. M. J. Nicoll, to Mr. H. N. Ridley, C.M.G., F.R.S., and to Lord Rothschild, F.R.S., whom I have to thank too for kind permission to make researches in the magnificent library in his Museum at Tring.

Information about mammals in captivity in Australia and America has been received from several sources, notably from Mr. A. C. Minchin (Adelaide), Mr. A. S. Le Souef (Sydney), Mr. A. Wilkie (Melbourne), Dr. C. Emerson Brown (Philadelphia), Dr. Raymond L. Ditmars (New York), Mr. L. J. Palmer (Bureau of Biological Survey, Washington, D.C.), and specially from the late Mr. Ned Hollister, whose early death is such a sad set-back to vertebrate zoology.

From 1896 to 1930 I have been so fortunate as to pay many visits to the Muséum Nationale d'Histoire naturelle, in the Jardin des Plantes, Paris, and have always received every help from the officials of that famous institution. I wish particularly to thank Prof. E. Bourdelle and Dr. Alfred Mouquet.

Two other Zoological Gardens where I have most particularly been made to feel "at home," and allowed to examine documents in, are those of Bâle and Rotterdam. Bâle was formerly under the directorship of the late Dr. G. Hagmann, and now under Dr. Adolf Wendnagel. The Director of the Rotterdam Z. G. who initiated accurate records of the animals was the late Dr. Johannes Büttikofer, who was succeeded by Dr. K. Kuiper.

The list of other friends and correspondents who have helped to supply the data on which this paper is based is a long one, and, alas, many of them are no longer with us, but I must record with gratitude certain names:—

Antwerp. Michel L'hoëst.

Berlin. Ludwig Heck and Ernst Schwarz.

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Cologne. L. Wunderlich and F. Hauchecorne.

Copenhagen. Julius Schiott and Th. Alving.

Dresden. Adolf Schoepf and G. Brandes.

Düsseldorf. Georg Aulmann.

Elberfeld. Keusch.

Frankfort o. M. Seitz and Kurt Priemel.

Hamburg. H. Bolau and M. A. Hans Bungartz.

Hanover. E. Schäff.

Leipzig. E. Pinkert and Johannes Gebbing.

Schönbrunn. Alois Kraus.

3. RECORDS OF LONGEVITY.

The literature on the subject of the longevity of mammals may be divided into three sections :—

1st. The very important paper by Mitchell (1911), with its admirable introduction (pp. 425–428), its summary of Lankester's distinctions in the significance of the word longevity, its explanations of the theory of Metchnikoff, and the vast array of figures conveniently arranged.

These figures for the London Z. G. are taken (p. 428) from “two manuscript folios, kept in the Prosectorium of the Society and covering the period from 1870 to 1902.”

Unfortunately, in these registers the dates of the arrivals of animals were not filled in with proper care; it is necessary in every case to verify them from the manuscript Daily Occurrence Books. It must also be remembered that these folios deal only with the animals that *died* during the period; if the animals that were sent away alive through sale or exchange and those that remained alive at the end of 1902 were also taken into account, the averages for some species would be distinctly higher.

2nd. List of length of life in particular collections :—Schmidt, 1880; Sanyal, 1892; Ferguson, 1901; Ridley, 1906; Flower, 1909, 1910; Brown, 1925.

3rd. Short notices in periodicals.

4. COMPARATIVE LONGEVITY OF MALES AND FEMALES.

Sir Humphry Rolleston (1927, p. 3) has stated that “women live longer than men,” and centenarian women exceed men in number—“In 1923 the numbers were 74 females and 22 males.” As regards mammals, other than mankind, the available statistics are not sufficient to prove the fact that females live longer than males, which is further complicated, both on the agricultural farm and in the zoological garden, by the fact that in so many species it is not economical to keep more than a few males alive in comparison to many their number of females. This matter will be returned to from time to time in the course of this paper.

5. GIZA ZOOLOGICAL GARDENS.

While Director of the Egyptian Government Zoological Gardens at Giza, near Cairo, I was able to keep careful records of the lives of the animals. These records were kept written up by myself from personal observation day by day when I was there, and when I was away from the entries in the manuscript Daily Occurrence Books, checked by examination of the actual specimens, the live ones in the menagerie and those that had died which were preserved in the Museum.

Summary of Mammals, by Orders and Families, that lived in the Giza Zoological Gardens during a period of 25½ years (October 1898 to March 1924 inclusive).

| | Number of forms. (Species and well-distinguished sub-species.) | Number of Individuals. | | | Average length of life of the twenty individuals that lived longest, with the number, out of the twenty, that left alive. | | | |
|--|---|------------------------|-------------|--------|---|---------|-------|------------------------------|
| | | Died. | Left alive. | Total. | Years. | Months. | Days. | Of these twenty, left alive. |
| 1. Primates. | | | | | | | | |
| 1. " Simiidae " | 3 | 9 | 2 | 11 | — | — | — | — |
| 2. Cercopithecidae | 36 | 361 | 168 | 529 | 15 | 11 | 24 | 15 |
| 3. Cebidae | 4 | 9 | 2 | 11 | — | — | — | — |
| 4. Hapalidae | 3 | 9 | 1 | 10 | — | — | — | — |
| Total Monkeys | 46 | 388 | 173 | 561 | 16 | 3 | 13 | 15 |
| 5. Lemnridae, <i>sens. lat.</i> | 28 | 232 | 18 | 320 | 17 | 6 | 27 | 8 |
| Total Primates | 74 | 620 | 261 | 881 | 19 | 1 | 2 | 14 |
| 2. Carnivora. <i>sens. lat.</i> | | | | | | | | |
| 6. Felidae | 13 | 163 | 119 | 282 | 9 | 9 | 24 | 5 |
| 7. Viverridae | 11 | 97 | 20 | 117 | 4 | 9 | 18 | 2 |
| 8. Hyæmidae | 2 | 26 | 7 | 33 | 7 | 11 | 12 | 3 |
| 9. Canidae | 11 | 208 | 102 | 310 | 9 | 5 | 17 | 6 |
| 10. Mustelidae | 11 | 79 | 14 | 93 | 2 | 5 | 18 | — |
| 11. Procyonidae | 3 | 1 | 3 | 4 | — | — | — | — |
| 12. Ursidae | 5 | 12 | 4 | 16 | — | — | — | — |
| 13. Phocidae | 1 | 1 | — | 1 | — | — | — | — |
| Total Carnivores .. | 57 | 587 | 269 | 856 | 14 | 0 | 16 | 4 |
| 3. Lipotyphla. | | | | | | | | |
| 14. Erinaceidae | 4 | 56 | 8 | 64 | 1 | 4 | 1 | — |
| 15. Soricidae | 3 | 34 | 3 | 37 | — | 6 | 5 | 2 |
| 16. Centetidae | 1 | 2 | — | 2 | — | — | — | — |
| Total Insectivores. | 8 | 92 | 11 | 103 | 1 | 5 | 5 | — |
| 4. Chiroptera. | | | | | | | | |
| 17. Pteropodidae | 2 | 29 | 7 | 36 | 6 | 9 | 8 | 7 |
| 18. Rhinolophidae | 2 | 2 | — | 2 | — | — | — | — |
| 19. Nycteridae | 1 | 2 | — | 2 | — | — | — | — |
| 20. Vespertilionidae | 3 | 2 | 3 | 5 | — | — | — | — |
| 21. Emballonuridae | 6 | 20 | — | 20 | — | — | — | — |
| Total Bats | 14 | 55 | 10 | 65 | 6 | 9 | 8 | 7 |
| 5. Rodentia, <i>sens. lat.</i> | | | | | | | | |
| 22. Sciuridae | 5 | 23 | 3 | 26 | 1 | 2 | 15 | 2 |
| 23. Muscardinidae | 2 | 3 | 1 | 4 | — | — | — | — |
| 24. Muridae | 35 | 425 | 221 | 646 | 3 | 10 | 26 | 1 |
| 25. Spalacidae | 2 | 13 | 1 | 14 | — | — | — | — |
| 26. Jaculidae | 3 | 114 | 34 | 148 | 4 | 2 | 26 | 10 |
| 27. Hystriidae | 3 | 12 | 4 | 16 | — | — | — | — |
| 28. Daayproctidae | 1 | 2 | 4 | 6 | — | — | — | — |
| 29. Caviidae | 1 | — | — | — | — | — | — | — |
| 30. Leporidae | 5 | 17 | 5 | 22 | 1 | 6 | 19 | 3 |
| Total Rodents | 57 | 609 | 273 | 882 | 6 | 10 | 19 | 4 |

| | Number of forms. (Species and well- distin- guished sub- species.) | Number of Individuals. | | | Average length of life of the twenty individuals that lived longest, with the number, out of the twenty, that left alive. | | | |
|--------------------------------|--|------------------------------|----------------|--------|---|---------|-------|------------------------------------|
| | | Died. | Left alive. | Total. | Years. | Months. | Days. | Of these twenty, left alive. |
| 6. Ungulata, sens. lat. | | | | | | | | |
| 31. Procaviidae | 4 | 47 | - | 47 | 3 | 9 | 17 | |
| 32. Elephantidae | 2 | - | 11 | 11 | | | | |
| 33. Rhinocerotidae | 1 | 1 | | 1 | | | | |
| 34. Equidae | 6 | 8 | 6 | 14 | | | | |
| 35. Bovidae | 55 | 691 | 477 | 1168 | 13 | 1 | 12 | 8 |
| 36. Giraffidae | 1 | 11 | 5 | 16 | | | | |
| 37. Cervidae | 4 | 12 | 4 | 16 | | | | |
| 38. Tragulidae | 2 | 11 | | 11 | | | | |
| 39. Camelidae | 3 | 5 | 20 | 25 | | | | |
| 40. Hippopotamidae | 1 | 1 | 2 | 3 | | | | |
| 41. Suidae | 6 | 18 | 3 | 21 | 8 | 1 | 24 | 2 |
| Total Ungulates | 85 | 805 | 528 | 1333 | 14 | 11 | 11 | 6 |
| 7. Tubulidentata. | | | | | | | | |
| 42. Orycteropodidae | 1 | 1 | 1 | 2 | | | | |
| 8. Xenarthra. | | | | | | | | |
| 43. Dasypodidae | 2 | 3 | 2 | 5 | - | | | |
| 9. Marsupialia. | | | | | | | | |
| 44. Macropodidae | 8 | 27 | 2 | 29 | 4 | 11 | 5 | 2 |
| 45. Phalangeridae .. | 3 | 3 | 1 | 4 | - | | | |
| 46. Phascolumiidae | 1 | 1 | - | 1 | - | | | |
| Total Marsupials.. | 12 | 31 | 3 | 34 | 4 | 11 | 26 | 2 |
| TOTAL MAMMALS. | 315 | 2803 | 1358 | 4161 | 19 | 6 | 2 | 12 |

Thus out of a collection of over four thousand mammals, taking the twenty individuals that lived longest in each Order, it appears that the Primates exceeded in longevity all other Orders not only in actual length of years, but also in that no fewer than fourteen out of the twenty individuals had not yet reached their limit but remained alive.

In descending scale the figures for the Giza Z. G. from October 1898 to March 1924, inclusive, are :-

| Order. | Average of 20 individuals. | | | Individuals left alive |
|-----------------------|----------------------------|--------|-------|------------------------|
| | Years | months | days. | |
| 1. Primates..... | 19 | 1 | 2 | 14 |
| 2. Ungulates..... | 14 | 11 | 11 | 6 |
| 3. Carnivores | 14 | 0 | 16 | 4 |
| 4. Rodents | 6 | 10 | 19 | 4 |
| 5. Bats | 6 | 9 | 8 | 7 |
| 6. Marsupials | 4 | 11 | 26 | 2 |
| 7. Insectivores | 1 | 5 | 5 | - |

Regarding the comparative longevity of male and female Mammals, in the Giza Z. G., October 1898 to March 1924, in only four groups are the comparative results worth publishing.

Monkeys.—Taking into consideration only those species in which it was possible to make a fair comparison between the sexes, the figures show that of 60 Monkeys (27 males, 33 females) of the genera *Cercopithecus*, *Erythrocebus*, *Papio*, and *Mandrillus*, the females live longer than the males, the calculated individual span of life for a male being 14 years 7 months and for a female 17 years 2½ months, or 2 years 7½ months longer. But of course sixty individuals is not a sufficient number to found a statement on; nevertheless, in the absence of more comprehensive statistics, it may be worth putting on record.

Lemurs.—Of 94 individuals (47 males, 47 females) of the genus *Lemur*, the average length of life of the sexes is approximately equal. Out of this number 13 males and 17 females left alive, which suggests that females have the greater viability; but, on the other hand, four individual males attained to greater ages than did any of the females.

Carnivora.—60 individuals (30 males and 30 females) of representative species give the following average durations of life :—

Males 9 years 2 months 21 days : 4, out of the 30, remaining alive.

Females . . 10 years 1 month 23 days : 5, out of the 30, remaining alive.

Thus the females exceeded the males by an average of 11 months 2 days. The five individuals that actually lived longest were all females.

Bovidae.—Of those species in which a fair comparison in numbers of the two sexes was possible, out of 170 individuals (85 males, 85 females), the males gave an average of 8 years 4 months, the females one of 8 years 2 months. 32 of the 85 males were left alive, but only 19 of the females.

6. NOTES ON ORDERS AND FAMILIES.

Order 1. PRIMATES.

Family PONGIDÆ (=part "Simiidae").

"The evidences are wholly convincing that at fifteen to eighteen years of age the great apes are wholly and fully grown. At what age senility begins to manifest itself has not been ascertained. . . . It is not unreasonable to assume that, under favourable conditions, any one of the great apes might live as long as does man." (R. M. Yerkes and A. W. Yerkes, 1929, p. 544.)

However, from individuals in captivity, all we know of their potential longevity is that both the Chimpanzee and the Mias may live to an age of about twenty-seven years.

Gorilla, *Gorilla gorilla*.

The Gorilla that has, so far, lived longest in Europe is the female "Pussi." She was purchased when believed to be about four years old, and arrived in the Breslau Z. G. 3.9.1897; she died 6.10.1904, as the result of a chronic kidney disease, having lived in Breslau 7 years 1 month 3 days.

Chimpanzee, *Pan satyrus* (*Anthropopithecus troglodytes*).

Chimpanzees live much better in captivity than do Gorillas; notes on twenty individuals show an average of over eleven years. The celebrated

"Sally," a female "Bald-headed Chimpanzee, *A. calvus*," lived in the London Z. G., 24.10.1883–28.8.1891, 7 years 10 months 4 days.

"Mimi," a female received in the Philadelphia Z. G., when believed to be seven years old, 24.5.1912, died 21.6.1923 (C. E. Brown, 1925, p. 265), after 11 years 27 days, at the probable age of 18 years. "Joanna," another female Chimpanzee in Philadelphia, received, when believed to be five years old, 22.6.1912, had to be killed, on account of illness, 25.5.1925—autopsy showed she had cancer (C. E. Brown, in letter of 23.3.1930)—after 12 years 11 months 3 days, also at the probable age of eighteen years.

A male Chimpanzee, seen living in the Pretoria Z. G. in June 1930 by Dr. S. Zuckerman, has been there for about fifteen years (R. Bigalke, 1929, p. 298).

Mr. A. S. Le Souef, in a letter of 12.5.1930, writes that the Schweinfurth's Chimpanzee living in the Taronga Zool. Park, Sydney, is now twenty-one years of age, and "it has gotten a greyish-white lower back, about two years ago."

The two Chimpanzees that have lived longest in the London Z. G. have both been males. One, 5.6.1904–12.1.1919, 14 years 7 months 7 days; the other, well known as "Mickie," 6.4.1898–7.6.1924, 26 years 2 months 1 day.

Orang Utan, or Mias, *Pongo pygmaeus* (*Simia satyrus*).

Mias rarely live over eight years in captivity. "Jacob," a male, was in the London Z. G., 5.2.1908–29.7.1916, 8 years 5 months 24 days. "Peter," a very big male in the Dresden Z. G., lived there, 1.10.1898–2.8.1907, 8 years 10 months 1 day. "Mollie," a female, was brought to the Melbourne Z. G. in 1900 when she was about a year old; she died there in September 1923, aged about twenty-four years. "Sandy," a male, lived in the Singapore Gardens for about eight years, and then in the London Z. G., 7.9.1905–10.3.1924, 18 years 6 months 3 days, so his age at death was at least twenty-six and a half years.

Family HYLOBATIDAE.

Gibbons reach maturity when about seven years old (R. I. Pocock, 1905, p. 170). Instances of their living in captivity to nine years are rare, though they may live to the age of at least twenty-four years.

The Hoolock, *Hylobates hoolock*, has lived nine years in the Calcutta Z. G. (Sanyal, 1892, p. 6). Two Gibbons of the Lar group have lived for over nine years in the London Z. G.: a *Hylobates agilis*, 16.12.1905–14.3.1915, 9 years 2 months 28 days, and a male *Hylobates leuciscus*, 8.5.1908–8.8.1917, 9 years 3 months. Sir Sydney Robinson (1925), in an interesting paper on Lar Gibbons in captivity in Burma, mentions one eighteen years old. A male Lar received in the Philadelphia Z. G. 26.7.1906 was "still living and well" 21.3.1930 (C. E. Brown, in a letter of 21.3.1930), after 23 years 7 months 23 days.

A Gibbon has lived in captivity in Hainan for about twelve years (R. I. Pocock, 1905, p. 173).

The longest record for a Siamang, *Symphalangus syndactylus*, appears to be the female in the London Z. G. which was purchased, for £50, 16.4.1925, and is still alive, 11.11.1930, after 5 years 6 months 25 days. (Note.—This Siamang died 13.1.1931.)

Family CERCOPITHECIDAE.

The Old-World Monkeys, regardless of size, appear to have an average life of under seven years, a specific longevity of about ten years, a full-span life of about fifteen years, and a potential longevity of about twenty-five to

thirty years: this potential longevity may be exceeded in the very large species,—instances are given of a Chacma of forty-five and of a Mandrill forty-six years old.

In the Giza Z. G. (*v. supra*, p. 151) females were found to live longer than males: another set of figures, compiled from various sources, of 114 Monkeys (56 males, 58 females) of this family give a male life of 11 years 10 months, and a female life of 11 years 3 months; that is to say, that the males lived five per cent. longer than the females. More statistics are required before the question can be settled.

The Langurs, the Monkeys of the genus *Pithecus* (*Semnopithecus*), seldom live to over seven or eight years in captivity in Europe. Representatives of two species have lived in the Calcutta Z. G. for ten years (Sanyal, 1892, p. 15), and a Nilgiri Langur once lived in the Trivandrum Z. G. for fifteen years (H. S. Ferguson, 1900–1901, p. 15). The African Colobus, or Guereza, Monkeys appear to be even more difficult than the Langurs to keep alive in captivity.

Eleven instances of long life in Monkeys of the genus *Cercopithecus* should be mentioned:—

| | Years | months | days. | |
|---|-------|--------|-------|------------------------|
| 1. <i>diana</i> . Calcutta Z. G. (Sanyal, 1892, p. 21) | 15 | 0 | 0 | |
| 2. <i>mona</i> "born in 1907." Rotterdam Z. G. 23.2.1909 9.11.1924 | 15 | 8 | 16 | age circa 17 years. |
| 3. <i>leucoppyx</i> . London Z. G. 28.12.1910 16.12.1926. | 15 | 11 | 18 | |
| 4. <i>mona</i> . Nat. Zool. Park. Washington, D.C. (A. B. Baker, 1927, p. 94) | 16 | 0 | 0 | |
| 5. <i>aethiops</i> ♀. Grivet. Giza Z. G. living 31.3.1924, after | 16 | 5 | 11 | and left alive. |
| 6. <i>subaenus</i> . Green Monkey. Chifton Z. G. living 22.9.1913. <i>vide</i> H. R. Woodward, after about | 16 | 6 | 0 | and left alive. |
| 7. <i>aethiops</i> ♀. Grivet. Giza Z. G. received when fully adult, died 21.4.1921. Lived in Giza | 17 | 1 | 23 | age at least 19 years. |
| 8. <i>talapoin</i> . Amsterdam Z. G. received in 1888, alive in Summer of 1907 About | 19 | 0 | 0 | and left alive. |
| 9. <i>sp.</i> ♂ Copenhagen Z. G. (Report, 1911, p. 28) | 20 | 0 | 0 | |
| 10. <i>mona</i> , ♀ Rotterdam Z. G. No. 1603 b 9.10.1901– 31.3.1924 | 22 | 5 | 22 | |
| 11. <i>aethiops</i> , ♀. Grivet. Caught in the Sudan, when quite young, in the Spring of 1900. Died in the Giza Z. G. in the Spring of 1924, when its teeth were still in good condition | 24 | 0 | 0 | |

The West African Patas Monkey, *Erythrocebus patas*, does not appear to do well in captivity, but a female Blue Nile Hussar Monkey, *Erythrocebus poliocephalus*, which died in the Giza Z. G. 12.12.1919, had lived there 14 years 4 months 2 days; and of a pair of the Kordofan race of the Dancing Red-Monkey, *Erythrocebus pyrronotus*, which were alive in the Giza Z. G. when I left there at the beginning of April 1924, the male had been at Giza 16 years 5½ months, and was a big adult animal when received, the female 19 years 1 month 9 days, and was at least a year old when received, so both these monkeys were over twenty years old and alive and well.

Mangabeys, *Cercocebus* spp.

There appears to be some difficulty in keeping Mangabeys in captivity as there are few available records of over ten years, and the longest, in the Lisbon Z. G. (Report No. 26, p. 21, 1909), is only fourteen years. A Sooty

Mangabey, *Cercocebus fuliginosus*, was in the London Z. G. 12.10.1914-23.6.1926, 11 years 8 months 11 days, and a pair of the same species that were alive in the Giza Z. G. 31.3.1924 had both been there over ten years, as the male had arrived 20.9.1913 and the female 22.12.1913.

Monkeys of the Genus *Macaca*

The Bonnet Monkey of southern peninsular India, *Macaca radiata* (*Macacus sinicus*), in the Trivandrum Z. G. "averaged" a life of twelve years, and one individual lived fifteen years (H. S. Ferguson, 1900-1901, p. 15); another individual, received at Trivandrum 29.12.1896, died of a wound 1.5.1909, thus living in captivity 13 years 4 months 4 days (S. S. Flower, 1914, p. 96).

The full life from birth of the Kra Monkey, *Macaca irus* (*Macacus cynomolgus*), in Singapore is fifteen years (H. N. Ridley, in letter of 19.2.1926), but individuals may live longer. Two in the Melbourne Z. G. (Report 1910, p. 9) were still alive after twenty years. One of twenty-two years (P. C. Mitchell, 1911, p. 432) lived to be twenty-five years old (R. I. Pocock, 1914, p. 844), and Dr. S. Zuckerman tells me that in June 1930 he saw in the Capetown Z. G., at Groot Schoor, two monkeys of this species, with "large patches on body denuded of hair," that are known to be twenty-seven years old.

The Bengal Monkey, *Macaca mulatta* (*Macacus rhesus*), in Calcutta lives to fifteen years (Sanyal, 1892, p. 23). In the Central Park Menagerie, New York, one was alive at the age of eighteen ('Osprey,' Sept. 1898, p. 12). In the Karachi Z. G. one is said to have lived nearly twenty years (S. S. Flower, 1914, p. 67). In the Melbourne Z. G. (49th Ann. Report. 1912, p. 7) several Rhesus are said to have lived to over fifteen years, and one to be alive at the age of twenty-four. An individual kept in India by Col. S. M. Benson (R. I. Pocock, 1906, p. 567, & 1913, p. 722) was probably twenty-nine years old at the time of its death.

Tcheli Monkey, *Macaca tcheliensis*.

It having been stated that a pair of these Monkeys, presented to the London Z. G. by Dr. Bushell in 1880, were still living in the Gardens in 1904, it is as well to have the actual facts in detail.

Six individuals were presented to the Society by Dr. S. W. Bushell, C.M.G., C.M.Z.S.; their periods of residence in the Gardens were as follows :—

| | Received. | Died. | Years months days. | | |
|--------------------------|------------|------------|--------------------|----|----|
| 1. ♂, about 1½ years old | 17.8.1880. | 21.3.1881. | 7 | 7 | 4 |
| 2. ♀, age ? | " | 6.3.1881. | 6 | 6 | 19 |
| 3. ♂, juv. | 17.6.1886. | 7.2.1904. | 17 | 7 | 20 |
| 4. ♀, " | " | 4.8.1886. | 1 | 1 | 17 |
| 5. ♂, " | 10.2.1900. | 21.4.1903. | 3 | 2 | 11 |
| 6. ♀, " | " | 29.1.1904. | 3 | 11 | 19 |

Japanese Monkey, *Macaca fuscata* (*Macacus speciosus*).

This species appear to do well in captivity in India, Egypt, Europe, and America. Seven definite records will illustrate this.

| | Years months days. | | |
|---|--------------------|---|--------------------|
| 1. ♀. London Z. G.: purchased 24.6.1904, died 24.11.1916... | 12 | 5 | 0 |
| 2. ♂. Philadelphia Z. G.: received 3.9.1915, still living and well 21.3.1930 (C. E. Brown, in letter of 21.3.1930). | 14 | 6 | 18 and left alive. |

| | Years months days. | | | |
|--|--------------------|---|----|------------------|
| 3. ♂, "born in Pulo Bali in 1907." Rotterdam Z. G.: received 21.6.1909, died 29.7.1924 | 15 | 1 | 8 | age c. 17 years. |
| 4. ♀. N. Z. P., Washington, D.C.: received 4.8.1904, died 7.12.1919 | 15 | 4 | 3 | |
| 5. ♂. N. Z. P., Washington, D.C.: received 4.8.1904, died 21.1.1920 | 15 | 5 | 17 | |
| This pair was received fully adult. In both cases the immediate cause of death was splenic tumour (N. Hollister, 1921, p. 80), | | | | |
| 6. Trivandrum Z. G.: purchased 7.2.1895; was destroyed, having gone blind, 2.12.1912 | 17 | 9 | 25 | |
| 7. ♀. London Z. G.: born 10.1.1906, killed 22.7.1925 | 19 | 6 | 12 | |

The Wanderoo Monkey, *Macaca silenus*, is usually a comparatively delicate animal in captivity, only living from five to ten years; but a male, believed to have been born in 1904, which was received in the Rotterdam Z. G. (No. 1949a) 17.5.1907, died 3.5.1924, after 16 years 11 months 16 days, at a probable age of about 19½ years.

The Barbary Ape, *Macaca sylvana* (*Macacus inuus*), is well known as a strong, hardy animal. A male lived in the Philadelphia Z. G., 18.6.1907–24.11.1928, 21 years 5 months 6 days, and a female purchased at Algiers, when believed to be three years old, lived for about two years on a yacht and was then brought to a house in Yorkshire, England, in 1878, where she lived for about twenty-two years and died 12.4.1900, aged about twenty-seven years (C. Duncombe, 1900). This is the individual mentioned by H. Scherren (1911, p. 281).

The Black Ape, *Cynopithecus niger*, seldom lives to ten years in captivity, but one of the "Batchian Race" was in the Singapore Gardens, 1891–1905, fourteen or fifteen years (H. N. Ridley, 1906, p. 145), and Mr. A. C. Hughes, in a letter to me of 12.11.1923, wrote that the specimen in the Mysore Z. G. was still alive after eighteen years.

Baboons, *Papio spp.*

Yellow Baboons, *Papio cynocephalus* (*Cynocephalus babouin*), often live ten to thirteen years in captivity. The late Dr. J. Anderson, F.R.S. (1902, pp. 55 & 82) has recorded one in the Cologne Z. G. of about fifteen years, and another, kept first in West Africa and later in the Hamburg Z. G., in all for about twenty-five years.

A Guinea Baboon, *Papio papio* (*Cynocephalus sphinx*), was still alive after sixteen years seven months in the Frankfort o. M. Z. G. (M. Schmidt, 1880, p. 302).

An Olive Baboon, *Papio anubis*, lived for over eighteen years in the Lisbon Z. G. (Report No. 26, 1909, p. 21). Three females received in the Giza Z. G., 25.12.1906, 13.9.1908, and 17.8.1909, were all still alive there 31.3.1924, after 17 years 3 months 6 days (age at least 19 years), 15 years 6 months 18 days and 14 years 7 months 14 days respectively. A very big male Anubis Baboon was for some years with the 13th Sudanese Battalion of the Egyptian Army; he was usually kept chained up near the guard room, but he bit so many people that he was sent to the Giza Z. G., where he arrived 19.12.1907 and died 15.11.1921, after 13 years 10 months 24 days, aged at least 20 years.

A male Chacma Baboon, *Papio porcarius*, received in the Philadelphia Z. G. 15.1.1908, was "still living and well" 21.3.1930 (C. E. Brown, in letter of 21.3.1930), after 22 years 2 months 6 days. Mr. A. C. Hughes, writing from Mysore, 12.11.1923 told me that a Chacma that he brought with him from South Africa to India lived to the age of forty-five years.

The Sacred Baboon, *Papio hamadryas*, in zoological gardens in Europe, North America, and India, not unfrequently lives from thirteen to fifteen years or longer. Two fine males that I saw from time to time in the Jardin Zool. d'Acclimatation, Bois de Boulogne, Paris, were in October 1911 believed to be eighteen years old. Two males received in the Cologne Z. G. as young specimens in 1886 were, in May 1910, well-grown beasts with grand grey mantles, and appeared very flourishing after twenty-four years in captivity. In the Giza Z. G., where Sacred Baboons did well and bred freely, I came to the conclusion that the males reached their full size and strength when eight to nine years old, and that they continued in their prime to when thirteen or fourteen years old, and then might begin to show signs of approaching senility. Twelve individuals living in the Giza Z. G. 31.3.1924 averaged 14 years 10 days; of these, one male and three females, imported from the Red Sea coastlands, had been 18 years 3 months 21 days in the collection; the others had been born in the menagerie.

A Mandrill, *Mandrillus sphinx* (*Cynocephalus mormon*), lived in the Jardin des Plantes, Paris, 15.4.1897-8.6.1913, 16 years 1 month 23 days. "Jinnie," the female Mandrill, which died in the Belle Vue Z. G., Manchester, in June 1900, is said to have lived there for 26 years 5 months. The male Mandrill, which died in the Calcutta Z. G. in 1913, was said to have lived there for 29 years. I doubt this, as the specimen is not mentioned by Sanyal (1892), at which time the animal would have been living for about eight years in Calcutta, a fact which Sanyal would not have overlooked. "George," the big male Mandrill formerly in the London Z. G., was deposited 30.11.1906 by the Hon. Walter Rothschild (now Lord Rothschild, F.R.S., V.P.Z.S.). It died 14.3.1916; on its card is the entry "about 40 years old." Lord Rothschild told me, 15.8.1913, that he purchased this Mandrill in Paris for £124, and that he was practically certain that it was an individual that had been imported into Europe in 1869. If this was so, its age at death was about 46 years.

Though the Mandrill often lives in zoological collections to ten years, and sometimes, as shown above, to much greater ages, records of the Drill, *Mandrillus leucophaeus*, exceeding ten years are rare. One was in the Frankfort o. M. Z. G. 14 years 19 days (M. Schmidt, 1880, p. 302), and the very big male (figured in the 'Field,' 18.3.1905) in the Belle Vue Z. G., Manchester, obtained in May 1895, when it was supposed to be about six months old, which died in July 1911, must have been at least 16½ years old.

Family CEBIDÆ.

The New-World Monkeys, unfortunately, live for such short periods in captivity that practically nothing is known of the natural duration of life of any genus except *Cebus*.

The statement that a Squirrel Monkey, *Saimiri sciurea* (*Chrysotrrix sciurea*), lived for nine years in the London Z. G. (P. Z. S. 1911, p. 432) is founded on a clerical error; but London holds the longest records, that I have been able to

find, for a Woolly Monkey, *Lagothrix humboldtii*, a male, 8.11.1919–21.10.1925, 5 years 11 months 13 days, and for a Spider-Monkey, *Ateles ater*, a female, presented 23.6.1924, still living 11.11.1930, after 6 years 4 months 18 days.

The Capuchin-Monkeys, *Cebus spp.*, give the idea that, if we could only keep them alive, American Monkeys may be really as long lived as African and Asiatic ones. Capuchins often live for nine years in captivity, sometimes for ten or eleven years, and rarely for twice that period. Three instances of good long-lived Brown Capuchins, *Cebus fatuellus*, are :—One I purchased in Liverpool, 2.10.1905, was still alive when I left Egypt in April 1924 18½ years later. In the Lisbon Z. G. (Report No. 26, pp. 20, 21, 1909) one lived for about 25 years. In the Philadelphia Z. G. (C. E. Brown, 1925, p. 265) one, "25 years old when received," 13.9.1917, died 1.10.1919, at the age of about twenty-seven years.

Family HAPALIDAE.

Dr. N. S. Lucas told me, 11.6.1930, that a female Marmoset, *Hapale jacchus*, which belonged to Mr. P. B. Tustin, was obtained when about one year old, and lived in London and other places in Europe for eleven and a half years; it died in the first half of 1930 at the age of about twelve and a half. Sir Peter Mitchell (1911, p. 434) has recorded a Marmoset, belonging to Miss C. Morey, being sixteen years old. The statement that a Silky Marmoset, *Leontocebus rosalia* (*Midas rosalia*), lived in the London Z. G. for over nine years (P. Z. S. 1911, p. 433) is founded on a clerical error. the individual was actually in the collection, 22.9.1879–28.11.1879, only two months six days.

Family LEMURIDAE.

Lemurs are long-lived animals for their size, 119 individuals selected to represent the principal species of the genera *Lemur*, *Hapalemur*, *Microcebus*, and *Chirogaleus*, show an average of nearly ten and a half years, with an extreme of twenty-six years. Forty-five males average a ten per cent. longer life than fifty-two females.

Details of twenty-one individual Lemurs are mentioned below to show, as far as known, maximum records by species and sexes :—

Ruffed Lemur, *Lemur variegatus* (*Lemur varius*).

| | | Years months days. | | |
|-------|---|--------------------|---|----|
| 1. ♀. | Giza Z. G.: received adult 20.4.1906, died 30.7.1916 | 10 | 3 | 20 |
| 2. ♀. | Rotterdam Z. G. received adult 18.4.1913, died 2.8.1926 | 13 | 3 | 14 |

Black Lemur, *Lemur macaco*.

| | | Years months days. | | |
|-------|--|--------------------|---|-------------------|
| 3. ♀. | Giza Z. G.: received adult 14.11.1903, died 6.8.1919 | 15 | 8 | 22 |
| 4. ♀. | Giza Z. G.: born 30.3.1906, living 31.3.1924 | 18 | 0 | 1 and left alive. |
| 5. ♂. | " " 14.11.1903, died 26.5.1923 | 19 | 6 | 12 |
| 6. ♂. | " " 13.4.1899, " 5.1.1921 | 21 | 8 | 22 |

Brown Lemur, *Lemur fulvus*.

| | | Years months days. | | |
|---------------------------|--|--------------------|---|----|
| 7. ♀, <i>nigrifrons</i> . | Giza Z. G.: born 14.4.1909, died 7.8.1923 | 14 | 3 | 23 |
| 8. ♂, " | Giza Z. G.: adult 1.10.1898, died 25.12.1914 | 16 | 2 | 24 |

| | | Years months days. | | | |
|-----|-----------------------|---|----|----|-------------------|
| 9. | ♀, <i>rufifrons</i> . | Giza Z. G. born 23.4.1906, living 31.3.1924 | 17 | 11 | 8 and left alive. |
| 10. | ♂, „ | Giza Z. G.: adult 26.12.1905, living 31.3.1924 | 18 | 3 | 5 „ „ |
| 11. | ♀, „ | Giza Z. G. adult 25.10.1905, living 31.3.1924 | 18 | 5 | 6 „ „ |
| 12. | ♂, „ | Giza Z. G.: adult 14.11.1903, living 31.3.1924 | 20 | 4 | 17 „ „ |
| 13. | ♂, "mongoz." | London Z. G.: 18.4.1882-22.1.1903 | 20 | 9 | 4 |
| 14. | ♂, <i>rufifrons</i> . | Giza Z. G. adult 1.10.1898, living, though blind and aged, 31.3.1924 At least | 25 | 6 | 0 and left alive. |

Mongoose Lemur, *Lemur mongoz* (*Lemur albimanus*).

| | | Years months days. | | |
|-----|----------------|---------------------|----|------|
| 15. | ♀. Giza Z. G.: | 14.1.1905-11.9.1923 | 18 | 8 27 |

Crowned Lemur, *Lemur coronatus*.

| | | Years months days. | | | |
|-----|---------------|---------------------------------------|----|---|-------------------|
| 16. | ♀. Giza Z. G. | 26.6.1906-22.12.1920 | 14 | 5 | 26 |
| 17. | ♂. „ | 25.10 1904-16.11.1920 | 16 | 0 | 21 |
| 18. | ♀. „ | received 25.10.1905, living 31.3.1924 | 18 | 5 | 6 and left alive. |

Ring-tailed Lemur, *Lemur catta*.

| | | Years months days. | | | |
|-----|----------------|---|----|----|----------------------|
| 19. | ♀. Giza Z. G. | received adult 4.10.1906, died 3.11.1919 | 13 | 0 | 29 |
| 20. | ♂. Giza Z. G.: | received when young 25.10.1904, killed by another <i>Lemur catta</i> ♂, 28.9.1919 | 14 | 11 | 3 |
| 21. | ♂. Giza Z. G. | received adult 16.4.1905, died 4.9.1923 | 18 | 4 | 18 over 20 years old |

Two other instances of long-lived *Lemur catta* must be noticed. Dr. G. Renshaw (1907, p. 17) writes of one received at the Jardin des Plantes, Paris, having "already lived nineteen years in Europe!," and Mr. T. H. Gillespie, in a letter of 9.4.1930, tells me of an individual received in the Edinburgh Z. G. in 1915, which died there in 1928—"it had been a lady's pet for some years before it came to us. . . . I understand at least for some nine or ten years"—so it was, perhaps, twenty-two years old.

A Grey Lemur, *Hapalemur griseus*, lived in the London Z. G., 9.8.1897-5.2.1909, 11 years 6 months 26 days, and another lived there 16.1.1899-22.2.1911, 12 years 1 month 6 days.

Coquerel's Pygmy-Lemur, *Microcebus coquereli* (*Chirogaleus coquereli*), does well in captivity in Europe; the records of two, both born in the London Z. G., are 10.8.1885-3.6.1899 and 20.8.1885-3.12.1900, 13 years 10 months 23 days and 15 years 3 months 13 days respectively.

Family LORISIDÆ.

A Slow Loris, *Nycticebus coucang*, has been recorded as living for ten years in the Calcutta Z. G. (Sanyal, 1892, p. 40).

Family GALAGIDAE.

male Garnett's Bush-Baby, *Galago garnettii*, lived in the Giza Z. G., 13.2.1905–30.11.1914, 9 years 9 months 18 days.

Family DAUBENTONIIDAE.

The real duration of life of the Aye-Aye, *Daubentonia madagascariensis* (*Chiromys madagascariensis*), is not known. Four instances of its life in captivity in Europe may be given :—

| | Years | months | days. |
|--|-------|--------|-------|
| 1. London Z. G. purchased for £5, 30.5.1911, died 9.2.1916 | 4 | 8 | 9 |
| 2. Jardin des Plantes, Paris 28.12.1921–4.6.1928 | 6 | 5 | 6 |
| 3. " " " 28.8.1907–16.6.1915 | 7 | 9 | 18 |
| 4. ♀. London Z. G. 28.10.1887–22.9.1896 | 8 | 10 | 24 |

INSECTIVORA.

(Orders 2-5. MENOTYPHLA, LIPOTYPHLA, CHRYSOCHLORIDEA, and DERMOPTERA.)

Practically nothing appears to be known of the duration of life of these animals—of only seven species have I been able to find records of individuals having lived in captivity for two years. Two, of these seven species, have lived to over three years, but none to four years. This does not prove that Insectivores are short-lived—it shows the difficulties of providing for their natural wants under artificial conditions.

A Bornean Tree-Shrew, *Tupaia tana*, lived in the London Z. G., 11.1.1881–9.5.1883, 2 years 3 months 28 days.

Of two North African Jumping-Shrews, *Elephantulus rozeti*, received in the Frankfurt a. M. Z. G. 19.11.1924, one lived to 19.3.1927, 2 years 4 months, and the other to 23.3.1928, 3 years 4 months 4 days.

The maximum for a European Hedgehog, *Erinaceus europaeus*, in the London Z. G. is, 19.9.1901–13.7.1904, 2 years 9 months 24 days. Four Algerian Hedgehogs, *Erinaceus algirus*, have lived to over two years in the London Z. G., the longest life being 9.5.1905–2.9.1907, 2 years 3 months 23 days. Of many Long-eared Hedgehogs, *Erinaceus auritus*, in the Giza Z. G., only two lived to over two years in captivity: one, a female, 13.8.1899–13.6.1902, 2 years 10 months, and one, sex not recorded, 4.1.1914–8.3.1917, 3 years 2 months 4 days. A Hardwicke's Collared Hedgehog, *Erinaceus collaris*, has lived for almost two and a half years in the London Z. G., 12.8.1927–9.2.1930, actually 2 years 5 months 27 days; the statement that one lived there for four and a half years (P. Z. S. 1911, p. 444) is founded on a clerical error.

G. E. H. Barrett-Hamilton (1911, pp. 81, 107, 108) has written on the longevity and mortality of Shrews, and of the British species of *Sorex* says :—“ it seems probable that the span of their natural existence is brief, perhaps not exceeding a year or thereabouts.” I. G. S. Montagu (1922, pp. 932, 933), writing of the European Shrew, *Sorex araneus*, shows that the theory of the Shrew being an annual animal, each generation surviving for about eighteen months, is not proved.

In the Giza Z. G. on two occasions an Egyptian Shrew lived in captivity for over a year. One of the larger species, *Crociodura olivieri*, 13.9.1903–17.11.1904, 1 year 2 months 4 days, and one, a female of the smaller species, *Crociodura religiosa*, 6.11.1913–8.2.1915, 1 year 3 months 2 days.

The Tenrec, *Centetes caudatus*, is disappointing in menageries, nineteen individuals average only ten and a half months : in the London Z. G. the longest record for a female appears to be 13.9.1901–17.8.1903, 1 year 11 months 4 days, and for a male, 8.11.1900–16.11.1902, 2 years and 8 days.

Order 6. CHIROPTERA.

Suborder MEGACHIROPTERA.

Several species of Fruit-Bats of the family Pteropodidae live so well in captivity that, for the purposes of this paper, they can be judged by the ordinary standard of longevity of mammals—that is to say, that the records of individuals that have lived for less than six years may be ignored as not throwing light on the problem of what is the life-span of the species.

Twenty-five individual Fruit-Bats, thus selected, show an average life of over nine years, with an extreme maximum of at least twenty years. Females average a longer life than males, but the number of individuals is far too small for a definite conclusion to be drawn on this point.

A female African Collared Fruit-Bat, *Rousettus leachi* (*Cynonycteris collaris*), of full size, said to have been born in the menagerie 21.2.1895, and certainly not later than 19.4.1898, which I received in exchange from the London Z. G., in London 17.7.1899, and took in my personal charge to Egypt, arrived in the Giza Z. G., 1.8.1899, and became very tame and a great pet. She died suddenly in the afternoon of 14.2.1918, having appeared to be in perfect health the evening before, and having come, as usual, to the cage-front when called and licked my finger. Other duties took me away from Giza for long periods during 1914–1919, but on returning to the Zoological Gardens there were certain animals that always gave me a welcome, and this bat was one of them. She weighed after death 27 kilos (say 9½ oz.), so was not emaciated by age. Special attention is called to this individual, as there was no possibility of mistaken identity ; her age was thus at least 19 years 9 months 25 days, and possibly 22 years 11 months 23 days.

Twenty Egyptian Fruit-Bats *Rousettus aegyptiacus*, seven out of the twenty being left alive, averaged a life in captivity in Giza of 6 years 9 months 8 days, the maximum being a female, 3.9.1903–2.5.1916, who had a known life of not less than 12 years 7 months 29 days.

The pair of Formosa Fruit-Bats, *Pteropus formosus*, the types of the species, which were presented to the London Z. G. 9.1.1873, lived well : the male died 4.10.1879, 6 years 8 months 25 days ; the female died 5.11.1880, 7 years 9 months 26 days. The Indian Fruit-Bat, *Pteropus giganteus* (*Pteropus medius*), does very well in captivity in Europe ; a female lived in the London Z. G., 1.10.1863–27.11.1880, 17 years 1 month 26 days, and a male in the Dublin Z. G., 10.8.1895–9.10.1903, 8 years 1 month 29 days. A female Australian Grey-headed Fruit-Bat, *Pteropus poliocephalus*, was in the London Z. G., 4.7.1868–13.6.1875, 6 years 11 months 9 days.

Suborder MICROCHIROPTERA.

Owing to the difficulties of keeping Insectivorous Bats in captivity, and to the very few cases so far recorded of marked, or banded, Bats being recaptured, little is known as to their duration of life.

A Noctule Bat, *Nyctalus noctula*, from Hever, Kent, presented by Mr. E. G. B. Meade-Waldo to the London Z. G. 10.12.1914, died 18.4.1915 ;

this, 4 months 8 days, is an exceptionally long time for any Insectivorous Bat to live in captivity.

A Long-eared Bat, *Plecotus auritus*, lived in private ownership in Germany, 26.11.1925–28.1.1927, 1 year 2 months 2 days (H. Kummerlöwe, 1929).

Two female American Brown Bats, *Eptesicus fuscus fuscus*, captured in a loft near Covina, California, 20.7.1921, were taken to Pasadena, some twenty miles away, banded, and released the same evening. On 16.6.1923 these two individuals were refound in the same loft where they had been caught nearly two years before; they were again taken to Pasadena and once more liberated (A. B. Howell and L. Little, 1924, p. 261).

British Bats "must reach a minimum of at least four years" (G. E. H. Barrett-Hamilton, 1911, p. 45).

Roux's Horseshoe-Bat, *Rhinolophus rouxi*, in India apparently seldom lives over four years in a wild state, and is not known to reach an age of five years (Knud Andersen, 1917).

Order 7. CARNIVORA.

(Carnivora vera, or Fissipedia.)

Most of the larger, and many of the median-sized species of Carnivora, do so well in captivity that they outlive their natural span of life—that is to say, that sheltered from the elements and from competitors in the struggle for existence, and with suitable food placed within their reach, they go on living to ages that they could not attain to in their wild state, and, as a plain matter of fact, the end of these old beasts has to be hastened, frequently with a bullet.

In exceptional cases it would appear that almost any carnivore might live to from seventeen to twenty years, Hyaenas, Lions, and other great cats to twenty-five years, and Bears even to thirty-five years.

Family FELIDAE.

319 individual members of this family, representing all the principal species, with the exception of the Domestic Cat, that have lived for over six years in various zoological collections show an average life of eleven years, and extremes of from sixteen to twenty-five years.

It is noteworthy that as far as the figures go there is not *much* difference either in average or in extreme age between the different species, though the largest species, the Lion, is the longest-lived. The Domestic Cat lives no longer than a wild cat might be expected to do under favourable circumstances; actually Domestic Cats have, in spite of their small size, almost the same life-span as Lions.

A comparison between a hundred males and a hundred females of various species of wild felines shows the females to be slightly longer lived than the males.

Lion, *Felis leo*.

The information available from zoological gardens and travelling menageries in Europe, supplemented by notes from America, Australia, and India, and the writer's personal acquaintance of this animal in Africa, combine to make our knowledge of the longevity of Lions more complete and reliable than that of any other wild mammal.

In 1900, in answer to enquiries, the authorities of the Jardin des Plantes, Paris, informed me that the average life to expect from the large Felidae was

four to five years, though individuals might live to ten, fourteen, or more years. This statement, viewed thirty years later, is absolutely correct.

Also in 1900 the late Dr. H. Bolau, Director of the Hamburg Z. G., told me to expect a Lion to live from four years to a maximum of eighteen years; Director E. Pinkert at Leipzig put the average at seven to eight years; Dr. G. Hagmann at Bâle at eight years. The Director of the Buda Pest Z. G. gave the average life in captivity there as eight to ten years. Inspector A. Kraus, of the Schönbrunn Menagerie, Vienna, also gave the average as eight to ten years, and the maximum as eighteen. The Director of the Posen Z. G., writing 27.4.1900, put the average as eight to twelve years. Dr. Kerbert, of Amsterdam, said the average was ten to twelve years, and Dr. Schâff, Director of the Hanover Z. G., in a letter of 4.5.1900, placed the average as high as twelve to fifteen years. As the maximum length of life to be expected, Hermann Stechmann, from his experience in the Breslau Z. G., said sixteen years, but Adolf Nil of Stuttgart, Prof. H. Landois of Münster, Inspector Goffart (then at Düsseldorf), and Heinrich Möller of the Aachen Z. G. all gave twenty years, while the then Directors of the Central Park Menagerie, New York, and of the Antwerp Z. G. put the maximum at twenty-five years.

A wild Lion in Africa is in his prime of life when five to six years old; after ten years his chances of remaining alive depend on his individual cleverness and the absence of competitors for food.

In the Giza Z. G., Oct. 1898–March 1924, the average of the twenty individuals, ten Lions and ten Lionesses, that lived longest was seven years eleven months twelve days, eight of the twenty being left alive.

One hundred individual Lions and Lionesses selected as those living longest from the available records of twenty-eight public zoological gardens give an average of thirteen years.

K. M. Schneider (1928) is correct in saying that in general a Lion or Lioness fifteen years old cannot be expected to live long.

Some exceptionally aged Lions are :—

| | | Years | months | days. | |
|--------|--|-------|--------|-------|-------------------|
| 1. ♂. | London Z. G.: 26.12.1877–31.1.1893 .. . | 15 | 1 | 15 | |
| 2. ♀. | "Duchess," from Somaliland, received at Nat. Zool. Park, Washington, D.C., "when about three years old," 17.12.1902, died 15.6.1918. "It is extremely doubtful if a wild lion ever reaches so advanced an age" (N. Hollister, 1919, p. 71) | 15 | 5 | 28 | age c. 18½ years. |
| 3. | Trivandrum Z. G. (H. S. Ferguson, 1900–1901, p. 15) . | 16 | 0 | 0 | |
| 4. ♀. | Central Park Menagerie, New York: purchased 20.7.1871, died 1888 (W. A. Conklin, 1889, p. 6) At least | 16 | 5 | 11 | |
| 5. ♀. | Giza Z. G.: 10.8.1902–9.4.1919 | 16 | 8 | 0 | |
| 6. ♀. | London, Z. G.: 8.9.1900–1.8.1917 | 16 | 10 | 23 | |
| 7. ♂. | „ 26.12.1877–21.12.1894 | 16 | 11 | 25 | |
| 8. ♀. | belonged to Capt. Alfred Schneider (K. M. Schneider, 1928) | 18 | 0 | 0 | |
| 9. ♂. | Bâle, Z. G.: 4.6.1890–9.11.1908 | 18 | 5 | 5 | |
| 10. ♀. | "Victoria," Clifton Z. G.: presented, when about two years old, in March 1895; living 22.9.1913. | 18 | 6 | 0 | and left alive. |
| 11. ♂. | Belle Vue Z. G., Manchester: died in March 1899 Circa | 19 | 0 | 0 | or 20 years old. |
| 12. | Adelaide Z. G. (25th Annual Report, 1902–1903, p. 16) A little over | 19 | 0 | 0 | |

| | Years | months | days. |
|--|-------|--------|----------------------------|
| 13. ♀, in Kreuzberg Menagerie, Herr Perzina (K. M. Schneider, 1928) | 22 | 0 | 0 |
| 14. ♀, born in 1903 in Carl Hagenbeck's Menagerie, died from old age in Rotterdam Z. G.: 13.11.1927. At least | 23 | 10 | 13 probably 24 years. |
| 15. ♂. "Nero," Cologne Z. G.: died between May 1907 and May 1908 Said to be about | 29 | 0 | 0 or nearly 30 years [old. |

It is unfortunate that no definite dates appear to have been preserved concerning "Nero." Dr. F. Hauchecorne has been so kind as to try to ascertain them; in a letter of 1.12.1930, he tells me that the oldest Lion in recent years in the Cologne Z. G. is "Prinz," received 11.9.1915, who is still living in extraordinary good health and with a hearty appetite. "Prinz" was the sire of cubs up to 1928, when he was twelve or thirteen years old.

The Dublin Zoological Gardens are famed for their Lions, and very justly so; with the kind assistance of Dr. B. B. Ferrar, the following details can be given of nine individuals that have been alive in Dublin within recent years:—

| | Years | months | days. |
|--|-------|--------|-----------|
| 1. ♀. "Fiona," born 19.10.1910, died 22.4.1926 | 15 | 6 | 3 |
| 2. ♀. "Sheila," " " " " 10.6.1926 | 15 | 7 | 21 |
| 3. ♀. "Maeve," " 29.3.1908. " 20.4.1925 | 17 | 0 | 21 |
| 4. ♀. "Niger," deposited 11.10.1905, died 17.10.1922 | 17 | 0 | 6 |
| 5. ♀. "Nigeria," " " " 23.10.1926 | 21 | 0 | 12 |
| 6. ♂. "Romulus," born 26.6.1889, died 9.2.1914 | 24 | 7 | 13 |
| 7. ♂. "Pluto," " " " " 14.7.1914 | 25 | 0 | 18 |
| 8. ♂. "Finn," born 29.1.1913 living 11.12.1930 | 17 | 10 | 12 alive. |
| 9. ♂. "Oseni," " 7.1.1913: " 11.12.1930 | 17 | 7 | 4 alive. |

A Tiger, *Felis tigris*, may be expected to live in captivity from four to five years. From information collected from twenty-one public zoological gardens in Europe, Africa, Asia, Australia, and North America we have notes of fifty individuals with an average life of eleven years. There appears to be no definite record of a Tiger living to twenty years, but it should be capable of living even longer. The following records of extreme longevity in Tigers should be mentioned in detail.

| | Years | months | days. |
|---|-------|--------|-------|
| 1. ♀. London Z. G.: 24.9.1892-22.2.1906 | 13 | 4 | 28 |
| 2. ♀. Dublin Z. G.: 2.7.1914-16.1.1928 | 13 | 6 | 4 |
| 3. Calcutta Z. G. (Sanyal, 1892, p. 45) | 14 | 0 | 0 |
| 4. Hamburg Z. G. (H. Bolau, in letter of 21.2.1900) | 14 | 0 | 0 |
| 5. ♀. London Z. G.: 27.4.1914-24.9.1928 | 14 | 4 | 27 |
| 6. Mysore Z. G. (A. C. Hughes, in letter of 12.11.1923) | 15 | 0 | 0 |
| 7. ♂. Pretoria Z. G. (R. Bigalke, 1929, p. 300). Nearly | 16 | 0 | 0 |
| 8. Trivandrum Z. G. (H. S. Ferguson, 1900-1901, p. 15) | 16 | 0 | 0 |
| 9. ♀. Belle Vue Z. G., Manchester: died in 1898 | 16 | 8 | 0 |
| 10. ♂. "Hans," Hanover Z. G.: died in 1905 or 1906. Circa | 17 | 0 | 0 |
| 11. Sydney Z. G.: longest record for a tiger—"by that time teeth were quite worn, and the animal had to be fed on minced meat" (A. S. Le Souef, in a letter of 12.5.1930) | 17 | 0 | 0 |

| | Years | months | days. | |
|--|-------|--------|-------|-------------------|
| 12. Adelaide Z. G. (24th Annual Report, 1901-1902, p. 19). | 18 | 0 | 0 | [old. |
| 13. ♀. Dublin Z. G. : 21.4.1906-24.11.1924 | 18 | 7 | 3 | probably 20 years |
| 14. ♀. Munster i. W. Z. G. (Schewior, 1928) | 18 | 0 | 0 | |
| 15. ♀. Cologne Z. G. This was a Siberian Tigress purchased 20.10.1911. Dr. Hauchecorne informed me that latterly she had eaten but little, and had difficulty in digesting such food as she ate, she died in October 1930 from extreme senile debility | 19 | 0 | 0 | |

Leopards, *Felis pardus*, average four to five years in captivity, but sixty individuals, selected from the longest records of over twenty public zoological gardens, give an average of nearly ten years. The specific longevity is probably between five and eight years, the potential longevity about twenty years.

Instances of unusual length of life to be mentioned specially :—

| | Years | months | days. | |
|---|-------|--------|-------|-----------------|
| 1. Hamburg Z. G. (H. Bolau, in letter of 28.2.1900) | 13 | 0 | 0 | |
| 2. ♀, <i>melas</i> . Bâle Z. G. : 7.5.1905-13.10.1918 | 13 | 5 | 6 | |
| 3. ♀. London Z. G. : 18.2.1878-12.8.1891 | 13 | 5 | 24 | |
| 4. ♂. „ 16.4.1878-17.12.1891 | 13 | 8 | 1 | |
| 5. Calcutta Z. G. (Sanyal, 1892, p. 51) | 14 | 0 | 0 | |
| 6. ♀. Nat. Zool. Park, Washington, D.C. : 19.12.1909-23.12.1923 (N. Hollister, 1925, p. 94) | 14 | 0 | 4 | |
| 7. ♀, <i>melas</i> . Trivandrum Z. G. : born 14.3.1899, living 26.4.1913 (S. S. Flower, 1914, p. 96) | 14 | 1 | 12 | and left alive. |
| 8. N. Z. P., Washington, D.C. : received 1909 (W. M. Mann, 1925, p. 90) | 14 | 6 | 0 | |
| 9. Mysore Z. G. (A. C. Hughes, in letter of 12.11.1923) | 16 | 0 | 0 | |
| 10. ♂. Dublin Z. G. : 21.5.1885-21.2.1902 | 16 | 9 | 0 | |
| 11. Lisbon Z. G. (Report No. 26, p. 21, 1909) | 18 | 0 | 0 | |
| 12. ♀. "Farooq," Giza Z. G. : died 2.6.1911 : was in my care for her last 12 years 8 months Probable age at death | 18 | 0 | 0 | |
| 13. <i>melas</i> . Mysore Z. G. (A. C. Hughes, in letter of 12.11.1923) . | 21 | 0 | 0 | |

Jaguars, *Felis onca*, do not often live to over six years in captivity, but when they do so they generally go on living for many more years ; thus fifteen Jaguars, two of them being still alive, average 14 years. In the Jardin des Plantes, Paris, one lived, 13.8.1892-14.11.1908, 16 years 3 months 1 day. "Bogie," a black female Jaguar, was purchased for £100 for the London Z. G. 12.4.1912 ; she died 4.1.1930, after 17 years 8 months 22 days. In the Copenhagen Z. G. a Jaguar, which died in 1910, was said to have lived for eighteen years. In the Hamburg Z. G. one lived for twenty years (H. Bolau, in letter of 28.2.1900) A female Jaguar purchased 26.10.1910, at what age is not known, for the Cologne Z. G., lived twenty years there, having died in October 1930, when she was still strong and well nourished, but was losing her eye-sight. The maximum record appears to be that of a female born in the Leipzig Z. G. in 1902, which died of old age in the Rotterdam Z. G. 25.5.1925, at least 22 years 4 months 25 days, probably 23 years old.

The Ounce, or Snow-Leopard, *Felis uncia*, has, so far, not done well in the London Z. G.—in fact a male which lived, 8.1.1894-1.5.1897, 3 years 3 months

23 days, is the only individual which has been over fourteen months there. In the Philadelphia Z. G. an Ounce lived 7 years 10 months 9 days (C. E. Brown, 1925, p. 265).

Domestic Cat, *Felis catus* (*Felis domestica*).

Cats, of both sexes, may be alive and well when thirteen years old, but fourteen to fifteen years is their ordinary extreme age, and out of the thousands of cats that are kept as domestic pets in Europe a few survive for an extra five or six years. In my own experience a cat of about eighteen had to be killed on account of its feebleness, and one of nearly nineteen died "well but worn out," these were both males. "Mike" of the British Museum, Bloomsbury, "Feb. 1909-Jan. 1929," appears to have lived to about nineteen years eleven months. Dr. Edwards Crisp (1860, p. 177) mentions a cat that had reached the age of twenty. Mr. H. N. Ridley, C.M.G., F.R.S., in letters of 19 & 26.2.1926, wrote of the oldest cat he knew, which belonged to Mr. Keeps; it lived to twenty-one; "when it died, it had lost all its teeth."

Cats may live to beyond twenty-one years. So far I have found no evidence to prove it, but in newspapers individual cats have been stated to be alive when twenty-seven, twenty-nine, and even when thirty-one years old, but dates or precise details are not given.

Wild Cats and Lynxes.

The European Wild Cat, *Felis silvestris*, was studied in captivity by the late Mr. Alfred H. Cocks, at Poynetts, Skirmett, Bucks. "The last wild cat died at the end of 1927, having lived sixteen years in captivity, which he (Cocks) considered a 'record'" (Records Bucks, 12, No. 3, p. 150. Aylesbury, 1929). This cat was, I believe, a female.

A female Jungle Cat, *Felis chaus*, lived in the Giza Z. G., 10.10.1900-27.1.1910, 9 years 3 months 17 days. Two *chaus* have lived longer than that in the London Z. G., 15.5.1895-13.10.1904, 20.4.1891-7.2.1901, 9 years 4 months 28 days and 9 years 9 months 17 days respectively.

A female Northern Lynx, *Felis lynx*, from Norway, lived in the London Z. G., 5.8.1876-11.9.1892, 16 years 1 month 6 days, and another female, *Felis lynx isabellina*, from Astor, lived there, 23.11.1882-1.10.1893, 10 years 10 months 8 days. A male Canadian Lynx, *Felis canadensis*, lived in the London Z. G., 1.4.1870-2.11.1881, 11 years 7 months 1 day, and a female Bay Lynx, *Felis rufa*, lived there, 25.6.1868-28.8.1878, 10 years 2 months 3 days. Important Lynx records from the National Zoological Park, Washington, D.C. (N Hollister, 1920, p. 72; 1921, p. 80; 1924, p. 92; 1925, p. 94; and W. M. Mann, 1927, p. 97) are of a Canadian Lynx, 25.9.1907-25.9.1918, 11 years; a Californian Lynx, 19.10.1905-23.9.1919, 13 years 11 months 4 days; two Bay Lynxes, 3.9.1907-22.1.1919, 15.1.1912-28.1.1927, 11 years 4 months 19 days and 15 years 13 days respectively; and two Uinta Lynxes, *Felis rufa uinta*, one, a male, 15.1.1912-28.10.1923, 11 years 9 months 13 days, the other, 3.9.1907-30.12.1922, 15 years 3 months 27 days, "died of old age."

The Caracal Lynx, *Felis caracal*, seldom lives over seven or eight years in captivity. The record for the Jardin des Plantes, Paris, is, 15.10.1903-20.2.1912, 8 years 4 months 5 days, for the Philadelphia Z. G. (37th Annual Report, p. 12) about nine years, and for the London Z. G., a female, 18.9.1879-

16.8.1890, 10 years 10 months 28 days. The Caracal is capable of living much longer, as is proved by a pair from the Sudan, which arrived in the Giza Z. G. 11.10.1910. They were sent off to the Dublin Z. G. 3.11.1910, where they arrived 23.11.1910; the male died 3.11.1926, the female 10.8.1927, 16 years 22 days and 16 years 10 months respectively.

Puma, *Felis concolor*.

Twenty-two Pumas that lived for over six years in captivity averaged 9 years 2 months. Six individual records may be given here :—

| | | Years | months | days. |
|-------|---|-------|--------|-------------------|
| 1. ♀. | London Z. G.: 14.8.1874-18.12.1884 | 10 | 4 | 4 |
| 2. ♂. | „ 1.9.1894-26.2.1905 | 10 | 5 | 25 |
| 3. ♂. | Rotterdam Z. G.: received 3.5.1887, died in 1899. | | | |
| | At least | 11 | 7 | 28 |
| 4. ♂. | Bâle Z. G.: 30.8.1899-25.10.1912 | 13 | 1 | 25 |
| 5. ♂. | Dublin Z. G.: received 28.11.1889, sold 30.3.1903 | 13 | 4 | 2 and left alive. |
| 6. | Hamburg Z. G. (H. Bolau. in letter of 28.2.1900) | 16 | 0 | 0 |

The Clouded Leopard, *Felis nebulosa*, one of the most beautiful of all the cat family, is, unfortunately, difficult to keep alive in captivity, but a female has lived in the London Z. G., 16.3.1899-19.3.1907, 8 years 3 days.

There appear to be few satisfactory records of life of all the other species of tropical wild cats. The best that I have been able to find so far are :—

A female Serval, *Felis serval*, London Z. G., 6.3.1891-11.5.1899, 8 years 2 months 5 days.

A Servaline Cat, *Felis servalina*, London Z. G., 4.6.1898-17.12.1906, 8 years 6 months 13 days.

The Indian Leopard-Cat, *Felis bengalensis*, has lived in the Singapore Gardens for twelve or thirteen years (H. N. Ridley, 1906, p. 151), and a male presented to the London Z. G. 22.5.1922, is still alive there, 11.11.1930, after 8 years 5 months 19 days.

A female Golden Cat, *Felis temminckii*, London Z. G., 19.8.1893-22.5.1904, 10 years 9 months 3 days.

A female Fishing Cat, *Felis viverrina*, lived in the London Z. G., 16.8.1870-8.12.1879, 9 years 3 months 22 days, and this species in the Calcutta Z. G. has lived for a few months over ten years (Sanyal, 1892, p. 56).

A male Ocelot, *Felis pardalis*, was in the London Z. G., 19.7.1883-26.3.1893, 9 years 8 months 7 days.

A Margay, *Felis tigrina*, in the Bâle Z. G., 30.7.1898-21.9.1911, 13 years 1 month 21 days.

An Eyra, *Felis eyra*, London Z. G., 7.7.1874-30.8.1883, 9 years 1 month 23 days.

A female Geoffroy's Cat, *Felis geoffroyi*, lived in the London Z. G., 21.11.1879-19.6.1888, 8 years 6 months 28 days.

The Chita, *Acinonyx jubatus* (*Cynaelurus jubatus*), seldom lives for more than six years in captivity. The longest period for the London Z. G. is, 22.8.1829-12.10.1836, 7 years 1 month 20 days, but the full life of the species is much longer; for instance, in the National Zoological Park, Washington, D.C. (W. M. Mann, 1927, p. 97, and 1929, p. 100), two Chitas were received 8.8.1913;

one died 17.2.1927, 13 years 6 months 9 days; the other 6.9.1927, 14 years 28 days; and in the Giza Z. G. a male Chita, received when young, 2.6.1901, lived till 16.1.1917, 15 years 7 months 14 days.

Family CRYPTOPROCTIDAE.

The Fossa, *Cryptoprocta ferox*, of Madagascar, appears to be a hardy animal in captivity in Europe. Of a pair received in the Jardin des Plantes, Paris, 14.4.1922, the female died 27.12.1929 and the male 9.1.1930, 7 years 8 months 13 days and 7 years 8 months 25 days, respectively, after their arrival.

A male Fossa in the London Z. G., purchased, when young, 12.11.1890, died 24.1.1905, after 14 years 2 months 12 days. A female, presented to the London Z. G. 11.8.1923, is still alive there, 11.11.1930, after 7 years 3 months.

A female Fossa died in the Hamburg Z. G. 21.5.1920, when about ten and a half years old, and a male, also at Hamburg, died in 1926, apparently of old age, when about seventeen years old. Both had been imported when young animals (J. Vosseler, 1929).

The female Fossa received in the Berlin Z. G. 4.11.1892 died 28.1.1909 (Prof. Ludwig Heck, in letter of 14.11.1930), after 16 years 2 months 24 days.

Family VIVERRIDAE.

In proportion to their size, the animals of this family appear to have high potential longevity. Genet, Mongoose, and Merkat may live to twelve or thirteen, Civet and Palm-Civet to fifteen or sixteen, and the Binturong to eighteen years.

A remarkable feature is that among the individuals that have been recorded as living longest there is such a large proportion of males.

Large Indian Civet-Cat, *Viverra zibetha*.

| | Years | months | days. |
|--|-------|--------|--------------------|
| 1. London Z. G.: 4.3.1898-19.3.1907 .. | 9 | 0 | 15 |
| 2. ♂. " 16.6.1874-8.5.1886 .. | 11 | 10 | 22 |
| 3. Calcutta Z. G. (Sanyal, 1892, p. 67) Nearly | 13 | 0 | 0 |
| 4. civettina. Trivandrum Z. G.: died before 15.4.1913 | 11 | 3 | 29 |
| 5. ♂, " " received 1.12.1897, living 26.4.1913 " .. | 15 | 4 | 25 and left alive. |

African Civet-Cat, *Civettictis civetta*.

| | Years | months | days. |
|--|-------|--------|---------------------|
| 1. Jardin des Plantes, Paris: 27.3.1902-18.1.1912 | 9 | 9 | 21 |
| 2. " " " 9.10.1911-29.11.1923 | 12 | 1 | 20 |
| 3. ♂. Giza Z. G.: received adult 17.8.1909, died 30.10.1919. | 10 | 2 | 13 age 12, or more. |
| 4. ♂. London Z. G.: 18.4.1873-2.1.1885 | 11 | 8 | 14 |
| 5. ♂. " 19.8.1887-25.4.1900 | 12 | 8 | 6 |
| 6. ♂. Bâle Z. G.: 7.4.1900-28.1.1914 | 13 | 9 | 21 |

Rasse Civet-Cat, *Viverricula malaccensis*.

| | Years | months | days. |
|---|-------|--------|-------|
| 1. ♀. Giza Z. G.: 15.12.1905-15.2.1913 | 7 | 2 | 0 |
| 2. ♂. London Z. G.: 30.8.1888-10.3.1891 | 7 | 8 | 10 |

Genets, *Genetta* spp.

Twenty-three selected individuals average a life of 7 years 8 months 10 days. The longest time that a Genet lived in the Giza Z. G. was only 6 years 8 months 9 days: this was a Dongola Genet, 6.10.1898-15.6.1905.

Eight authentic cases of long-lived Genets may be stated in detail :—

| | | Years | months | days. |
|----------------------------------|---|-------|--------|-------|
| 1. ♀, <i>genetta</i> . | London Z. G. : 7.6.1886-22.11.1894 | 8 | 5 | 15 |
| 2. <i>senegalensis</i> . | Jardin des Plantes, Paris : 7.4.1897-2.1.1906 | 8 | 8 | 25 |
| 3. <i>tigrina</i> . | London, Z. G. : 27.6.1887-28.9.1896 | 9 | 3 | 1 |
| 4. <i>rubiginosa</i> . | „ 20.7.1907-1.3.1917 | 9 | 7 | 11 |
| 5. ♂, <i>tigrina</i> . | „ 2.8.1871-25.10.1881 | 10 | 2 | 23 |
| 6. <i>pardina</i> . | „ 3.9.1914-30.5.1925 | 10 | 8 | 27 |
| 7. <i>genetta</i> , from France. | Jardin des Plantes, Paris : 15.6.1907-16.2.1919 | 11 | 8 | 1 |
| 8. ♂, <i>pardina</i> . | London Z. G. : 15.4.1882-31.8.1894 | 12 | 4 | 16 |

Attention must be called to the fact that it has been stated that a Burmese Tiger-Civet, or Linsang, *Prionodon maculosus*, said to have been received in the Breslau Z. G. 2.6.1897, lived there till 19.7.1915—that is to say, for 18 years 1 month 17 days. Dr. Schlott, in a letter from Breslau of 11.8.1930, tells me that the date of reception of the animal is not certain, and that the late Prof. Matschie identified it as *Genetta suahelica*, a race of the African *Genetta tigrina*.

Palm-Civets, *Paradoxurus* spp.

Twenty-one selected individuals average a life of 8 years 5 months 8 days. Six instances of *Paradoxures* living to over ten years :—

| | | Years | months | days. |
|----------------------------|--|-------|--------|--------------------|
| 1. <i>larvatus</i> . | London Z. G. : 21.7.1900-12.4.1911 | 10 | 8 | 21 |
| 2. <i>hermaphroditus</i> . | Philadelphia Z. G. : 20.12.1909-30.5.1922 (C. E. Brown, 1925, p. 265) | 12 | 5 | 0 |
| 3. <i>leucomystax</i> . | Jardin des Plantes, Paris. 18.8.1900-11.5.1913. | 12 | 8 | 23 |
| 4. ♂, „ | London Z. G. : 8.6.1886-2.4.1900 | 13 | 9 | 24 |
| 5. ♂, <i>niger</i> . | Trivandrum Z. G. : received 14.11.1898, living 26.4.1913 | 14 | 5 | 12 and left alive. |
| 6. <i>larvatus</i> . | London Z. G. : 10.5.1877-27.10.1892 | 15 | 5 | 17 |

A male Binturong, *Arctictis binturong*, received in the Trivandrum Z. G. 8.12.1901, was living there 26.4.1913, after 11 years 4 months 8 days. The oldest known Binturong appears to be one that, having passed sixteen years in captivity in the Singapore Gardens (H. N. Ridley, 1906, p. 153), arrived in London 7.9.1905, and died there 18.4.1907, when about eighteen years of age.

Small-toothed Palm-Civets, *Arctogale leucotis*, have lived in the London Z. G., 11.3.1878-11.5.1886 and 21.2.1887-6.2.1898, 8 years 2 months and 10 years 11½ months respectively.

Although the West African Two-spotted Palm-Civet, *Nandinia binotata*, is brought so frequently to Europe, few individuals live for over six years. A male presented to the London Z. G. 10.7.1920 is still alive, 11.11.1930, after 10 years 4 months 1 day.

Mongooses.

The Egyptian Mongoose, *Herpestes ichneumon*, occurred wild in the Giza Z. G., but we had no success in keeping it in captivity for periods of much over five years, the maximum record being of a male, 18.1.1906–30.5.1911, 5 years 4 months 12 days. This period has been exceeded at least five times in the London Z. G., where the two longest records are of the Spanish Mongoose, *Herpestes ichneumon widdringtonii*.

| | | | Years | months | days. |
|-------|------------------------|--------------------|-------|--------|-------|
| 1. ♀. | 7.4.1898 | 17.2.1904 | 5 | 10 | 10 |
| 2. | 11.5.1892 | 9.10.1898 | 6 | 1 | 28 |
| 3. ♂. | 4.6.1868 | 18.1.1875 | 6 | 7 | 14 |
| 4. ♀. | <i>widdringtonii</i> . | 19.3.1880 | 7 | 0 | 17 |
| 5. | „ | 3.2.1881–27.9.1888 | 7 | 7 | 24 |

The Grey Mongoose, or “Common Indian Mongoose,” *Herpestes nyula* (*Herpestes griseus*), is given a life in captivity in Bengal of two years by Sanyal (1892, p. 74), and of the scores that are brought alive to Europe very few live to even two years after importation. In all the history of the London Z. G. I find only four certain instances of this Mongoose living to over three years, the maximum being, 12.12.1896–30.7.1901, 4 years 7 months 18 days. There is, however, the case of a male Mongoose, which was identified both as *griseus* and as *smithii*, which lived, 15.12.1897–27.4.1903, 5 years 4 months 12 days. In the Trivandrum Z. G. a Grey Mongoose is reported to have lived for eight years (H. S. Ferguson, 1900–1901, p. 16).

Other species of Asiatic Mongoose do better in captivity: thus the Spotted Mongoose, *Herpestes auro-punctatus*, has lived in the Calcutta Z. G. for a few months over six years (Sanyal, 1892, p. 74), and one lived in the London Z. G., 19.1.1904–1.4.1911, 7 years 2 months 12 days. The records in the London Z. G. are, for a Ruddy Mongoose, *Herpestes smithii*, 13.10.1898–30.8.1904, 5 years 10 months 17 days, and for a Ceylon Brown Mongoose, *Herpestes fulvescens*, 6.4.1904–28.8.1909, 5 years 4 months 22 days.

A male Striped-necked Mongoose, *Herpestes vitticollis*, was in the Trivandrum Z. G. 12 years 10 months 18 days (S. S. Flower, 1914, p. 96), and a Javan Mongoose, *Herpestes javanicus*, lived in the London Z. G., 3.7.1834–13.2.1841, 6 years 7 months 10 days.

The beautiful, elegant, but rather stupid White-tailed Mongoose, *Ichneumia albicauda*, is not easy to keep in captivity for many years, yet in the London Z. G. one lived, 3.11.1905–2.12.1915, for the remarkable long period of 10 years 29 days.

Other notable successes in the London Z. G. are for the Dusty Mongoose, *Galerella pulverulenta*, 13.11.1899–1.9.1907, 25.5.1870–29.3.1878, 30.8.1862–16.5.1871, respectively 7 years 9 months 18 days, 7 years 10 months 4 days, 8 years 8 months 17 days, and for a male Pusa Mongoose, *Bdeogale pusa*, 12.10.1892–30.8.1903, 10 years 10 months 18 days.

Ten individuals of the Zebra Mongoose, *Mungos mungo* (*Crossarchus fasciatus*), average a life of 5 years 9 months 18 days: the longest for the London Z. G., 1.4.1868–28.12.1875, is 7 years 8 months 27 days, and a female purchased

in Khartoum 1.6.1905, which arrived in the Giza Z. G. 10.8.1905, died 6.1.1914, 8 years 7 months 5 days.

The Yellow or Levaillant's Meerkat, *Cynictis penicillata*, has on two occasions exceeded a life of twelve years in the London Z. G., 5.1.1876-24.2.1888, 12 years 1 month 19 days, and 22.3.1897-24.1.1910, 12 years 10 months 2 days; but the true Meerkat, *Suricata suricatta*, seldom lives long, the maximum certain record for the London Z. G. being, 8.9.1922-28.11.1928, 6 years 2 months 20 days.

Family PROTOLIDAE.

A male Aard-Wolf, *Proteles cristatus*, lived in the London Z. G., 20.5.1869-11.4.1882, 12 years 10 months 21 days. No other individual has lived for even half so long. Nothing else appears to be known of the life-span of this rare animal.

Family HYAENIDAE.

The Striped, the Brown, and the Spotted Hyaena, are all long-lived animals. Fifty-four individuals in fourteen different collections had an average life of twelve years and maximums of from twenty-three to twenty-five years. Males and females appear to be equally long lived, but the numbers are too few to draw definite conclusions from, and Spotted Hyaenas, in life, may be sexed wrongly.

Striped Hyaena, *Hyaena hyaena*.

| | Years months days. | | |
|--|--------------------|----|--------------------|
| 1. From India. London Z. G.: presented 15.6.1831, died 21.1.1843; this is the correct date of death, not 4.10.1843, as has been stated | 11 | 7 | 6 |
| 2. "Ibbi," belonged to Mrs. A. L. Butler; killed in 1914. <i>Carca</i> | 13 | 0 | 0 in England. |
| 3. Trivandrum Z. G. (H. S. Ferguson, 1900-1901, p. 16) | 13 | 0 | 0 and left alive. |
| 4. Belle Vue Z. G., Manchester: died in Jan. or Feb. 1902 | 13 | 8 | 0 |
| 5. ♂, from Egypt. Giza Z. G. received 21.4.1906, died 29.1.1921 | 14 | 9 | 8 age c. 16 years. |
| 6. Jardin des Plantes, Paris: 19.11.1899-10.5.1917 | 17 | 5 | 21 |
| 7. Copenhagen Z. G. (Report 1911, p. 28) | 20 | 0 | 0 |
| 8. ♀, from Sudan. Giza Z. G.: received 7.4.1901, living 31.3.1924, when she had lost most of her teeth and looked decrepid, but still enjoyed life, and, as she always had been, was tame and friendly | 22 | 11 | 24 age c. 24 years |

Brown Hyaena, *Hyaena brunnea*.

| | Years months days. | | |
|---|--------------------|---|----|
| 1. London Z. G.: 12.11.1900-17.1.1912 | 11 | 2 | 5 |
| 2. ♂. Rotterdam Z. G.: 5.4.1888-8.7.1900 | 12 | 3 | 3 |
| 3. Philadelphia Z. G.: 7.6.1888-27.1.1901 (C. E. Brown, 1925, p. 265) | 12 | 7 | 20 |
| 4. ♀. London Z. G.: 3.3.1853-13.8.1866 | 13 | 5 | 10 |

Spotted Hyaena, *Crocuta crocuta*.

| | Years months days. | | |
|---|--------------------|---|-----------------------|
| 1. ♂. London Z. G.: presented 21.5.1867, died 5.7.1880. | 13 | 1 | 14 |
| 2. ♀. " " " " 20.7.1880. | 13 | 1 | 29 |
| 3. Edinburgh Z. G.: received Aug. 1913, died Dec. 1926. | 13 | 3 | 0 aged when received. |

| | Years | months | days. | |
|---|-------|--------|-------|-------------------------------------|
| 4. ♀. Rotterdam Z. G.: 11.3.1884-20.9.1898 | 14 | 6 | 9 | |
| 5. Philadelphia Z. G.: received 19.4.1907, sold 19.6.1923 (C. E. Brown, in letter of 21.3.1930) | 16 | 2 | 0 | and left alive. |
| 6. Jardin des Plantes, Paris: 28.8.1884-10.10.1901 | 17 | 1 | 2 | |
| 7. ♀, from Suakin; in captivity there from before Sept. 1894. In Giza Z. G. 14.6.1900-27.10.1918. Died of old age | 18 | 4 | 13 | [2 months. probable age 24 years |
| 8. ♀, from Blue Nile. In Giza Z. G. 19.3.1901 2.1.1920. Died of old age | 18 | 9 | 13 | age c. 19½ years. |
| 9. Rotterdam Z. G.: 27.11.1905-4.7.1925. Died of old age | 19 | 7 | 7 | age c. 21 years |
| 10. Lisbon Z. G. (Report No. 26, 1909, p. 21) <i>Circa</i> | 21 | 0 | 0 | |
| 11. Philadelphia Z. G.: 10.11.1874-30.1.1896 (C. E. Brown, 1925, p. 265) | 21 | 2 | 20 | |
| 12. Hamburg Z. G. (Report for 1902, p. 10) | 24 | 1 | 0 | |
| 13. ♂. The "Billy" of Frank Buckland's 'Curiosities of Natural History' <i>Circa</i> | 25 | 0 | 0 | |

The actual facts of this Hyaena's life, so far as I can piece them together, are that the animal was obtained alive by W. J. Burchell, the traveller, for the Rev. Dr. W. Buckland, the geologist, who purchased it in 1821. It lived in Cross's menageries, first at Exeter Change in London and later at the Surrey Zoological Garden, where it died 14.1.1846 (*cf.* W. H. Flower, 1884, p. 110, and A. D. Bartlett, 1898, p. 15).

Family CANIDAE.

Ninety-five Dingos, Wolves, Jackals, and Coyotes that have done well—that is to say, have lived for over 6 years in captivity—give an average life of 9 years 8 months 21 days, and extremes of from thirteen to seventeen years. This is interesting as giving evidence as to the probable life-span of the "unimproved," or original, Domestic Dog having been the same as that of the Domestic Dogs of to-day.

Sixty-one Foxes of various species give an average life of 7 years 6 months 20 days, with extremes of ten to fourteen years.

In both the Wolf group and the Fox group males show rather longer lives than females, but the numbers of individuals are too few to allow a definite conclusion to be drawn on this point.

Domestic Dog, *Canis familiaris*.

Dogs get a reputation for longevity because they are so numerous. It comes as a surprise to most people to be told that the average age of a dog in England, without counting deaths among young puppies, is probably well under four years.

The healthy mind dwells naturally on those dogs which have been long and faithful companions of oneself and of one's friends, and not on those which have been failures or have soon, by accidents, come to tragic ends.

The full life of a dog is something quite different from the average life. It is beyond the scope of this paper to give an account of the lengths of life that may be expected from dogs of various breeds. Most men and women have had their own personal experience of their favourite dogs.

When a dog has reached ten to twelve years he is an old dog, but, exceptionally, whether male or female, may live much longer. Even little fancy animals,

as Yorkshire Terriers and King Charles Spaniels, may live to ages of thirteen to fifteen; Sheep Dogs and Collies to fifteen or sixteen. Terriers appear to be exceptionally long-lived, even to sixteen and eighteen years. "Sailor," a male Field-Spaniel, lived, to eighteen (W. H. Flower, 1884, p. 119). Very rarely one meets a live dog with an authentic history of twenty years, and then one may wish, for the animal's sake, that its end may be near. Instances of dogs of twenty-two and of thirty-four years of age have been recorded (P. C. Mitchell, 1911, p. 441, thirty-four after Lankester, 1870, p. 60).

The three longest records in the London Z. G. for the Dingo, *Canis familiaris dingo*, are those of a pair received 26.10.1889 of which the female died 15.3.1901 and the male 16.11.1901, 11 years 4 months 19 days and 12 years 20 days respectively, and of a female which lived in the menagerie, 13.3.1901-7.2.1914, 12 years 10 months 24 days.

Wolf, *Canis lupus*.

Thirty Wolves had an average life of 9 years 10 months 12 days. A female from New Mexico lived in the London Z. G., 16.10.1901-17.4.1915, 13 years 6 months 1 day. A Wolf in the Copenhagen Z. G. (Report for 1911, p. 28) 14 years. A male Grey Wolf, *Canis lupus nubilus*, in the National Zoological Park, Washington, D.C., 16 years 3 months 5 days (N. Hollister, 1923, p. 93).

Indian Wolf, *Canis pallipes*.

A male in the London Z. G., purchased from Jamrach 10.3.1848, has been stated to have been still alive on 1.1.1863; this is quite probable, but, so far, I have been unable to verify the fact. Another male was in the London Z. G., 20.4.1888-27.11.1900, 12 years 7 months 7 days.

Jackals.

The specific identification of Jackals is sometimes very difficult, if not impossible. In captivity the North African and Asiatic Jackals, although they are smaller animals, show both average and extreme lengths of life comparable to those of Wolves. In the Jardin des Plantes, Paris, a Jackal that had been purchased in June 1831 died in May 1848 (E. Oustalet, 1900, pp. 378, 379), when at least 16 years 10 months old. A male Jackal, said to have come from Abyssinia, purchased by the London Z. G. in 1848, which died 3.7.1865, is believed to have lived in London for over 16½ years. Oriental Jackals have lived for over twelve years in the Trivandrum Z. G., and for over fifteen years in the Calcutta Z. G. (Sanyal, 1892, p. 80).

Five definite instances of long life in the Egyptian Wolf-like Jackal, *Canis lupaster*, are :—

| | | Years months days. | | | |
|-------|---|--------------------|----|----|------------------------|
| 1. ♀. | Giza Z. G.: from before 1.10.1898, died 13.5.1910. | 11 | 7 | 13 | age c. 14½ years. |
| 2. ♂. | " received, when young, 26.11.1898, died 19.11.1911 | 12 | 11 | 23 | age c. 13½ years. |
| 3. ♂. | " trapped, fully adult, 31.8.1901, died 25.6.1916 | 14 | 9 | 25 | age at least 16 years. |
| 4. | Jardin des Plantes, Paris: 10.8.1900-27.12.1913 | 13 | 4 | 17 | |
| 5. ♀. | London Z. G.: 31.5.1897-6.1.1912 | 14 | 7 | 7 | |

The Coyote, *Canis latrans*, agrees with Wolves and Old-World Jackals in length of life. One lived in the London Z. G., 18.2.1899-28.4.1911, 12 years

2 months 10 days. Of a pair received in the National Zoological Park, Washington, D.C., 24.6.1906, the female died 10.6.1920, "virtually helpless with disabilities of old age," after 14 years 1 month 14 days; the male lived till 28.9.1920, 14 years 5 months 2 days (N. Hollister, 1921, p. 80, and 1922, p. 89).

The Black-backed Jackal, *Canis mesomelas*, although smaller than any of the *Canis* species already mentioned, also lives well: nineteen individuals give an average of 8 years 4 months 12 days, the maximum being in the London Z. G., 15.1.1858–18.9.1871, 13 years 8 months 3 days. There is also in the London Z. G. a possible, but not certain, case of a Black-backed Jackal living from 3.2.1851–24.3.1865, 14 years 1 month 21 days.

Foxes.

Several Foxes, *Vulpes vulpes*, from the British Isles, from continental Europe, and from Asia, have lived in the London Z. G. for more than eight years. The two longest London records for English Foxes appear to be of one, 17.6.1908–1.12.1916, 8 years 5 months 14 days, and of a white male from Essex which was deposited by the Hon. Walter Rothschild (now Lord Rothschild, F.R.S., V.P.Z.S.) 7.2.1905, and died 30.11.1914, 9 years 9 months 23 days. The longest period that an Egyptian Fox, *Vulpes vulpes aegyptiaca*, lived in the Giza Z. G., 30.3.1912–8.8.1919, was 7 years 4 months 8 days: it was a vixen.

That the average age of the American Red Fox, *Vulpes fulva*, in the London Z. G. is greater than that of the Old World Red Fox, *Vulpes vulpes*, is probably accounted for by the eliminating effect of the Atlantic crossing; but that the maximum records for the American Fox are greater than those of the European Fox must be due to some other cause. Three of the longest records in the London Z. G. for *Vulpes fulva* are, 4.7.1912–18.7.1922, 10 years 14 days; a Cross Fox, 12.12.1910–10.10.1921, 10 years 9 months 28 days; and a male, deposited 10.11.1876, which lived till 1.12.1888, 12 years 21 days.

An Indian Desert Fox, *Vulpes leucopus*, lived in the London Z. G., 5.1.1909–9.11.1919, 10 years 10 months 4 days.

The very beautiful little Sand-Fox, *Vulpes rüppelli* (*Canis famelicus*), looks so pretty, appears happy, and is sometimes very tame in captivity, but does not appear to live long under artificial conditions. The maximum in the Giza Z. G., one obtained 17.3.1930, which was left alive there 31.3.1924, was only just over four years, but that is longer than the records, so far as ascertained, for several European menageries. In the London Z. G. one Sand-Fox has lived longer, 25.8.1880–27.1.1887, 6 years 5 months 2 days.

The true Fennec Fox, *Vulpes zerda* (*Canis cerdo*), is hardier in captivity than the Sand-Fox. One lived in the Jardin des Plantes, Paris, 30.8.1921–21.11.1927, 6 years 2 months 21 days; one in the London Z. G., 10.10.1866–6.12.1875, 9 years 1 month 26 days; and the maximum record for the Giza Z. G. was that of a male, received 10.1.1910, which had to be killed as showing signs of senile decay, 7.7.1920, 10 years 5 months 27 days.

A North American Grey Fox, *Urocyon cinereoargenteus*, was in the London Z. G., 14.9.1908–14.2.1917, 8 years 5 months.

The Arctic Fox, *Alopex lagopus*, lives well in England. Ten individuals in the London Z. G. averaged 8 years 9 months 18 days, the two longest being 27.9.1887–10.9.1898, 10 years 11 months 13 days, and 2.4.1898–29.7.1910, 12 years 3 months 27 days. In the Belle Vue Z. G., Manchester, a male Arctic Fox had to be shot 31.1.1905, at the age of fourteen.

Very little appears to be known of the life-spans of the South American Foxes. The longest records in the London Z. G. for the three following species are:—

| | Years | months | days. |
|---|-------|--------|-------|
| Colpeo Fox, <i>Pseudalopex culpaeus</i> , ♂: 6.7.1870–24.11.1878 | 8 | 4 | 18 |
| Azara's Fox, <i>Pseudalopex gymnocercus</i> : 4.3.1895–6.4.1904 | 9 | 1 | 2 |
| Argentine Grey Fox, <i>Pseudalopex grisens</i> : 21.7.1916–5.1.1924 | 7 | 5 | 14 |

Antarctic Wolf, *Dusicyon australis* (*Canis antarcticus*).

This "Wolf" being extinct, all available details should be put on record. Four individuals have been exhibited alive in the London Z. G.:—

| | Years | months | days. |
|--|-------|--------|-------|
| 1. Presented 12.6.1845 by Mr. W. Brown; died 8.5.1846 | — | 10 | 26 |
| 2. " 31.8.1852 by Mr. A. Ross-lafon; died 8.12.1852 | — | 3 | 8 |
| 3. Received 24.8.1868, having been collected by Monsieur A. A. Leconte; died 26.1.1870; body sent to Mr. Gerrard | 1 | 5 | 2 |
| 4. Presented 8.11.1870 by Mr. H. Byng; died 2.3.1876 | 5 | 3 | 24 |

The body of this individual was sent also to Mr. Gerrard.
This animal was a female according to P. Z. S. 1870, pp. 797, 909, but a male according to the Society's MS. register of deaths, 2.3.1876.

Maned Wolf, *Chrysocyon brachyurus* (*Canis jubatus*).

It would be of great comparative interest to know what is the life-span of this remarkable animal, a giant fox on stilt-like legs, but, so far, no records of its having lived to even five years in captivity have been found.

Very little appears to be known of the duration of life of the members of the other genera of the Canidae. A female Raccoon-like Dog, *Nyctereutes procyonoides*, born in the London Z. G. 2.5.1877, lived to 27.3.1883, 5 years 10 months 25 days. A Delalande's Long-eared Fox, *Otocyon megalotis*, was in the London Z. G., 16.2.1847–25.8.1852, 5 years 6 months 9 days. A female Indian Wild Dog, *Cuon dukhunensis*, was still alive after nine years in the Trivandrum Z. G. (H. S. Ferguson, 1900–1901, p. 16). A Malay Wild Dog, *Cuon rutilans* (*Canis javanicus*), lived in the London Z. G., 4.6.1920–20.12.1927, 6 years 6 months 16 days.

The Cape Hunting-Dog, *Lycaon pictus*, has lived for between six and seven years in the zoological gardens of London, Manchester, and Giza, and for longer periods in Dublin, where this species had bred. Of a pair received in the Dublin Z. G. 5.10.1894, the male died 13.10.1903, 9 years 8 days, and the female lived till 2.12.1904, 10 years 1 month 27 days.

Family MUSTELIDÆ.

Practically nothing appears to be known of the duration of life of the smaller Musteline animals, or of the very large species, the Sea-Otter and the Wolverine. The medium-sized forms that do well in captivity show great potential longevity, Martens, Badgers, and American Badgers living to fourteen or fifteen, Otters to sixteen, the Tayra to seventeen, and the Ratel to twenty-four years.

So far as the available figures go, the length of life of males and of females is about equal.

Otters, *Lutra* spp.

Otters are difficult to determine specifically when alive, but with the small differences of structure between the species and the great similarity in habits it is probable that the life-span is fairly equal in the different forms comprising the genus. On the other hand, the information collected from various sources is conflicting. W. H. Hurt Sitwell (1906, p. 736) gave 5 years 3 months as a good life for a British Otter, but A. H. Cocks (1906, p. 822) mentioned 10 years 10 months. The Director of an important zoological garden in Europe wrote, 30.11.1925, that Otters in captivity "do not live well, never more than three years": while I have notes on eighteen individual Otters, of perhaps three species, whose average age is 8 years 5 months.

The European Otters in the London Z. G. look happy and well, but the majority do not live long; in fact, in only about seven instances can it be found that an individual has lived there for over five years. Some have escaped alive from Regent's Park; others have met with accidents, as in the case of the Otter presented by Sir Rowland Hill 1.2.1834, which was "suffocated under the ice in his pond" 22.12.1835. The maximum record for London is of a male Otter, presented by the Rev. P. M. Brunwin 11.3.1846, which lived till 23.12.1852, 6 years 9 months 12 days; but perhaps the most interesting records are those of the two Otters which were born in the Menagerie 13.8.1846; both lived for over six years, as one died 21.8.1852, the other 18.9.1852.

Other instances of the life of *Lutra lutra* in Europe are:—Bale Z. G., received 23.1.1923, living 19.7.1930, 7 years 5 months 26 days. Frankfort o. M. Z. G., 8 years 5 months 23 days (M. Schmidt, 1880, p. 304). Jardin des Plantes, Paris, 8.5.1903–2.12.1912, 9 years 6 months 24 days. Bâle Z. G., 31.7.1897–23.10.1908, 11 years 2 months 23 days.

A female Florida Otter was in the National Zoological Park, Washington, D.C., 20.7.1907–20.3.1920, 12 years 8 months (N. Hollister, 1921, p. 80).

An Indian Otter, *Lutra tarayensis* (*Lutra ellioti*) lived in the Calcutta Z. G. 11 years 4 months (Sanyal, 1892, p. 90). On 26.4.1913 there were two male Otters living in the Trivandrum Z. G.: one, *Lutra lutra* (*Lutra vulgaris*), received 11.9.1900, had been there 12 years 7 months 15 days; the other, *Lutra tarayensis* (*Lutra macrodus*, *Lutra ellioti*), received 2.11.1897, had been there 15 years 5 months 24 days (S. S. Flower, 1914, p. 96).

Weasels.

The longest records in the London Z.G. for the Weasel, *Mustela nivalis* (*Mustela vulgaris*), are of two individuals received 27.4.1893, one of which lived till 15.3.1899, 5 years 10 months 18 days, and the other till 13.2.1901, 7 years 9 months 16 days. An Egyptian Weasel, *Mustela africana* (*Mustela subpalmata*), lived in the London Z. G., 12.5.1897–16.11.1903, 6 years 6 months 4 days.

The Polecat, *Putorius putorius*, does not appear to live long in zoological gardens. It may do better when in private ownership: thus H. Scherren (1908, p. 513) mentions one, belonging to A. H. Cocks, living for over six years, and E. G. B. Meade-Waldo, in a letter of 20.2.1926, tells me that he has known a Polecat to live in captivity for thirteen years.

Martens, *Martes* spp.

The Pine-Marten, *Martes martes*, was a favourite species with the late Mr. A. H. Cocks, at Poynetts, Skirmett, Bucks; the average of seven individuals there was 12 years 9 months, and the maximum over fifteen years (H. Scherren, 1908, p. 513). The Pine-Marten also lives well in public menageries; the average of seven individuals, five in London and two in Bâle, is 8 years 10 months 8 days. The maximum for London appears to be a male, 13.11.1874–11.10.1883, 8 years 10 months 28 days, and for Bâle a female, 22.6.1904–21.1.1918, 13 years 7 months.

The Beech-Marten, or Stone-Marten, *Martes foina*, is another delightful animal in captivity. One lived in the Philadelphia Z. G., 31.3.1914–9.8.1924, 10 years 4 months 9 days (C. E. Brown, 1925, p. 265), and a female in the London Z. G., purchased 7.12.1920, is still alive there, 11.11.1930, after 9 years 11 months 4 days.

Two male American Martens, *Martes americana*, have been reported as still living, but showing signs of age, when ten years old (F. G. Ashbrook and K. B. Hanson, 1930, p. 3), and another American species, the Pekan or Fisher-Marten, *Martes pennanti*, lived in the London Z. G., 6.10.1860–7.1.1871, 10 years 3 months 1 day.

A male Tayra, *Tayra barbara*, lived in the London Z. G., 21.6.1873–11.4.1879, 5 years 9 months 20 days, but six females in London averaged 7 years 9½ months, the maximum being, 11.5.1921–14.5.1930, 8 years 11 months 27 days. A female Tayra lived in the National Zoological Park, Washington, D.C., 8.9.1914–20.3.1924, 9 years 6 months 12 days (N. Hollister, 1925, p. 95). This does not represent the potential longevity of the species, as a Tayra received in the Frankfort o. M. Z. G. in April 1913 was still living there 15.9.1930, after 17 years 4½ months.

Badgers.

The European Badger, *Meles meles*, frequently lives to seven or eight years of age. One living in the Belle Vue Z. G., Manchester, early in 1925 was over nine years old. Another was in the Rotterdam Z. G., 27.7.1907–1.1.1917, 9 years 5 months 3 days. An individual was in the London Z. G., 20.10.1920–7.11.1930 10 years 17 days. The late Mr. A. H. Cocks, at Poynetts, "kept a badger for fourteen years and three months, when it dislocated a shoulder and had to be killed" (H. Scherren, 1908, p. 513).

The Japanese Badger, *Meles anakuma*, does very well in the London Z. G., where five individuals have had an average life of 10 years 9 months 18 days, the maximum being, 18.3.1895–27.12.1909, 14 years 9 months 9 days.

The Ratel, or Honey-Badger, *Mellivora ratel*, is noted for its longevity. Five instances may be given :—

| | Years | months | days. |
|--|-------|--------|-------|
| 1. Philadelphia Z. G.: 28.6.1910–27.6.1922 (C. E. Brown, 1925, p. 265). | 11 | 11 | 29 |
| 2. ♀, from Suakin. London Z. G.: 10.7.1890–4.5.1907 | 16 | 9 | 5 |
| 3. ♀, type of <i>leuconota</i> . „ 3.8.1866–4.12.1883 | 17 | 4 | 1 |
| 4. Jardin des Plantes, Paris: 8.4.1883–5.5.1904 | 21 | 0 | 27 |
| 5. ♂. London Z. G.: 15.7.1890–27.1.1914 | 23 | 6 | 12 |
| "Probably not less than twenty-five years old" (R. I. Pocock, 1914, p. 354). | | | |

A Cape Striped-Weasel, *Ictonyx capensis*, lived in the London Z. G., 9.4.1894–17.9.1899, 5 years 5 months 8 days, and a Libyan Striped-Weasel, *Ictonyx libyca*, in the Giza Z. G., 2.5.1914–3.12.1918, 4 years 7 months 1 day.

Four American Badgers, *Taxidea taxus*, in the London Z. G. averaged eleven years, the maximum being a male, 23.8.1910–7.7.1924, 13 years 10 months 14 days.

The longest period that a Grison, *Grison furax* (*Galictis vittata*), has lived in the London Z. G. appears to be, 21.5.1883–24.8.1890, 7 years 3 months 3 days, and for a Canadian Skunk, *Mephitis mephitis*, 29.12.1910–29.1.1917, 6 years 1 month.

Family PROCYONIDAE.

The real longevity of these animals is not known—we only know their response to a life in captivity. This, for individuals who have done well, is: for Kinkajous nine to ten years, with an extreme of twenty: for Raccoons eight years, with an extreme of sixteen: and for Coatis six to seven years, with an extreme of perhaps eleven years.

So far as the figures at my disposal go, males and females are equal in length of life.

A Cacomistle, *Bassariscus astutus*, lived in the Philadelphia Z. G., 26.4.1916–16.7.1924, 8 years 2 months 20 days (C. E. Brown, 1925, p. 265).

A female Kinkajou, *Potos flavus* (*Cercoleptes caudivolvulus*), was in the National Zoological Park, Washington, D.C., for 11 years 1 month 5 days (N. Hollister, 1923, p. 93). In the Jardin des Plantes, Paris, the longest record for a Kinkajou is, 5.5.1912–3.4.1926, 13 years 10 months 28 days. In the London Z. G. a male Kinkajou lived, 6.5.1901–8.10.1912, 11 years 5 months 2 days, and a female deposited, when, it is said, fully adult, 2.8.1911, is still alive 11.11.1930, after 19 years 3 months 9 days.

A Raccoon, *Procyon lotor*, lived in the Jardin des Plantes, Paris, 5.10.1893–12.6.1902, 8 years 8 months 7 days. A male was in the Rotterdam Z. G., 30.9.1890–6.5.1900, 9 years 7 months 6 days, and an albino Raccoon was in the London Z. G., 6.5.1884–27.2.1898, 13 years 9 months 21 days. A female Crab-eating Raccoon, *Procyon cancrivorous*, lived in the London Z. G., 2.3.1880–7.1.1896, 15 years 10 months 5 days.

A Coati, *Nasua sp.*, died in the Belle Vue Z. G., Manchester, in February 1899, after having lived there for ten years and one month.

So little is known about the life-span of the Panda, *Ailurus fulgens*, of the family Ailuridae, that no conclusions can be drawn.

Family URSIDAE.

Bears of all species live well under suitable conditions of captivity. A selection of 178 individuals, representing all species, show an average life of over 16 years 2 months. The extreme age for a Bear is not less than 34 years.

45 males averaging 16 years 2 months and 57 females averaging 15 years 8 months indicate that there cannot be much difference in the longevity of the sexes.

Polar Bear, *Thalarctos maritimus*.

Polar Bears often live in captivity for 16 to 17 years, and a few live for much longer, as the following instances show :—

| | | Years | months | days. | |
|-------------------------------|---|-------|--------|-------|------------------|
| 1. ♀ | "Barbara," London Z. G.: purchased, for £25, 19.9.1904, died 28.1.1923 | 18 | 4 | 9 | |
| 2. Jardin des Plantes, Paris: | 25.9.1890-24.2.1912 | 21 | 5 | 0 | |
| 3. " | " received 12.10.1908, living 18.5.1930 | 21 | 7 | 6 | and left alive. |
| 4. ♂ | "Sam," London Z. G.: purchased, for £18 18s. 0d., 3.11.1903, died 23.8.1925 | 21 | 9 | 20 | |
| 5. ♂ | London Z. G.: presented 9.12.1871, died 22.11.1894 | 21 | 11 | 13 | |
| 6. ♂ | Adelaide Z. G.: purchased 18.4.1908, living 22.10.1930 | 22 | 6 | 4 | and left alive. |
| 7. ♂ | Adelaide Z. G.: purchased 18.4.1908, living 22.10.1930 | 22 | 6 | 4 | and left alive. |
| 8. ♂ | Nill's Z. G., Stuttgart: about 3½ years old in summer of 1875, died in summer of 1898 (H. Scherren, 1907, p. 434) Circa | 26 | 6 | 0 | |
| 9. ♂ | Dublin Z. G.: presented 23.11.1900, died 24.9.1928 | 27 | 10 | 1 | age c. 32 years. |
| 10. ♀ | London Z. G.: purchased for £31 10s. 0d., 7.9.1846 (not 28.9.1846, as has been stated), died 26.1.1880. | 33 | 4 | 9 | |

Brown Bear, *Ursus arctos*.

E. T. Bennett (1830, p. 105) wrote that in 1771 a pair of Bears were living in the celebrated pits at Berne, Switzerland, which had been there for thirty-one years, and that another Bear, that had been born in the Berne Bear Pits, was in 1801 living in the Jardin des Plantes, Paris, at the age of forty-seven years. The first statement is probable, the second doubtful; but, all the same, Brown Bears are very long-lived animals. Fifty-eight individuals, of which I have notes on as having "done well," average nineteen years, but as thirty out of these fifty-eight animals were still living when the information came into my hands, the eventual average would be very much greater than nineteen years.

The individual Brown Bears with the longest records in the London Z. G. are :—

| | Years | months | days. |
|---|-------|--------|-------|
| 1. ♀, <i>isabellinus</i> : 16.4.1898-21.5.1918 | 20 | 1 | 5 |
| 2. ♀, <i>arctos</i> : 31.12.1890-14.5.1912 | 21 | 4 | 14 |
| 3. ♀, <i>syriacus</i> : 3.3.1879-13.11.1900 | 21 | 8 | 10 |
| 4. ♂, <i>piscator</i> : 14.9.1867-29.6.1893 | 25 | 9 | 15 |
| 5. ♀, <i>syriacus</i> : presented 5.5.1910, living 11.11.1930 | 20 | 6 | 6 |
| 6. ♀, <i>beringianus</i> : presented 30.9.1910, living 11.11.1930 | 20 | 1 | 11 |
| 7. ♀, <i>arctos</i> : presented 5.11.1910, living 11.11.1930 | 20 | 0 | 6 |

Examples of long-lived Brown Bears from other zoological gardens are :—

| | Years | months | days. |
|--|-------|--------|--------------------|
| 1. Jardin des Plantes, Paris: 1.10.1904-29.4.1929 | 24 | 6 | 8 |
| 2. " " " received 9.7.1904, living 18.5.1930 | 25 | 10 | 9 and left alive. |
| 3. ♂, Belle Vue Z. G., Manchester: died during 1913 | 26 | 0 | 0 |
| 4. ♂, "born 1902." Received in Rotterdam Z. G. 4.5.1903, living there 31.5.1930 | 27 | 0 | 26 and left alive, |

| | Years months days. | | |
|--|--------------------|---|-------------------|
| 5. ♂. "Mischka," born in Russia in February 1902, living in Rotterdam Z. G. 31.5.1930 .. . | 28 | 3 | 0 and left alive. |
| 6. ♀. Nill's Z. G., Stuttgart: about 2½ years old in summer of 1875, was shot in 1906 (H. Scherren, 1907, p. 434) .. . | Circa 33 | 3 | 0 |
| 7. <i>Ursus</i> "behringi," Schönbrunn, Vienna: living in April 1910 (S. S. Flower, 1911, p. 422) .. . | Circa 34 | 0 | 0 |

Grizzly Bear, *Ursus horribilis*.

The great Brown Bears of western North America are also long lived in captivity: twelve individuals, five of them being left alive, average 21 years 3 months.

About 1813 the Hudson Bay Company presented a Grizzly Bear to King George III.; it was kept in the Tower of London till 17.1.1832, when King William IV. presented it to the Zoological Society. It was the last of the animals of the historic old Tower Menagerie to be transferred to the Zoological Gardens in Regent's Park. It died 30.10.1838, after 26 years of life in London.

Two female Bears "from the Missouri Brakes, Montana," which were presented to the London Z. G. 4.10.1890, equalled or excelled the Tower Bear in longevity, as one died 3.10.1916 and the other had to be killed 3.4.1918, 26 years and 27½ years respectively.

Two Bears in the National Zoological Park, Washington, D.C., should be mentioned specially: a Kadiak Bear, which lived there 15.12.1903–28.8.1927, 23 years 8 months 13 days, and a Yakutat Bear that was alive in 1928 when 28 years old (W. M. Mann, 1929, pp. 97, 100).

The Cologne Z. G. (Report, 1911, p. 6) had a Grizzly Bear for thirty years.

American Black Bear, *Ursus americanus*.

The Black, and Cinnamon, Bears, of the subgenus *Euarctos*, are not as long lived as the Brown, and Grizzly, Bears. Thirty-three individuals give an average of a little over 14 years, and extreme old age appears to be at about 26 years, as compared with 34 in the Brown Bear.

The three longest records for this species in the London Z. G. are all of the variety known as the Cinnamon Bear, *Ursus americanus cinnamomum*: one was a male, 6.12.1894–19.6.1913, 18 years 6 months 13 days, the other two were both presented by the Hudson Bay Company, 23.10.1829; one died 11.11.1848 and one 28.5.1851, 19 years 8 days and 21 years 7 months 5 days respectively.

A male Kenai Peninsula Black Bear, *Ursus americanus perniger*, received, when about two years old, in the National Zoological Park, Washington, D.C., 5.3.1903, died 23.6.1921 (N. Hollister, 1922, p. 89) having lived 18 years 3 months 18 days in the Park, and being about 20 to 20½ years old. The Philadelphia Z. G. has two long records of Black Bears, 12.8.1905–25.2.1924, 18 years 6 months 13 days, and 17.11.1902–15.11.1922, 19 years 11 months 28 days (C. E. Brown, 1925, p. 266).

A pair of Black Bears at Silver Lake Park, near Akron, Ohio, were both living at the age of twenty-four years (A. A. Baker, 1912).

A female *Ursus americanus* received in the Frankfort o. M. Z. G. 9.1.1884, lived there till 15.12.1909, 25 years 11 months 6 days, when it was killed by an *Ursus tibetanus*.

Himalayan Black Bear, *Ursus tibetanus*.

Sixteen individuals average 15 years 8 months. The longest record for the Jardin des Plantes, Paris, appears to be, 12.7.1886–25.4.1903, 16 years 9 months 13 days, and for the London Z. G., a female, 16.11.1888–6.9.1906, 17 years 8 months 20 days. One that I saw in the Frankfort o. M. Z. G. in September 1912 was said to have been living there for 18 years. The Bâle Z. G. has a definite record of a female, 9.5.1904–19.5.1923, 19 years 10 days. One has lived in the Trivandrum Z. G. for 19 years (H.S. Ferguson, 1900–1901, p. 16); another was in the Mysore Z. G., 1895–1922, about 27 years (A. C. Hughes, in a letter from Mysore of 12.11.1923); and for Calcutta an age of 33 years has been given (Sanyal, 1892, p. 103).

A female Japanese Bear, *Ursus japonicus*, lived in the London Z. G., 1.4.1862–2.7.1872, 10 years 3 months 1 day, and a female Spectacled Bear, *Ursus ornatus*, purchased 9.7.1874, died 3.2.1888, after 13 years 6 months, 24 days in London.

Malay Bear, *Ursus malayanus*.

Seventeen individuals average 11 years 7 months. In the Bâle Z. G. a female lived, 5.8.1905–11.11.1918, 13 years 3 months 6 days. In the Philadelphia Z. G. (43rd Annual Report, p. 19, 1915) a female lived for 18 years, and in the Lisbon Z. G. (Report No. 26, p. 21, 1909) a Malay Bear lived for over 20 years. The three longest records for the London Z. G. appear to be: a male, 4.12.1889–30.7.1904, 14 years 7 months 26 days; a female, 12.3.1902–4.2.1917, 14 years 10 months 22 days; and a female, 14.8.1873–13.3.1894, 20 years 6 months 29 days.

Sloth-Bear, *Melursus ursinus*.

Only twelve instances of Sloth-Bears living to over six years in captivity have been collected so far: these twelve individuals, three of which were left alive, averaged 11 years 4 months. A male was in the London Z. G., 5.11.1897–16.8.1914, 16 years 10 months 11 days. A male in the Trivandrum Z. G. was still living after 18 years 2 months 13 days (S. S. Flower, 1914, pp. 96, 97). In the National Zoological Park, Washington, D.C., a Sloth-Bear has lived for 21 years 6 months (A. B. Baker, 1927, p. 94).

Order 8. PINNIPEDIA.

Family OTARIIDAE.

Sea-Lions do well in captivity, twenty-four individuals, that lived for over six years in various collections, averaged thirteen and a half years. It appears that the maximum age they can attain to is over twenty-three years. So far as the available figures show, the sexes are equal in length of life.

Individual records to mention specially are:—

Californian Sea-Lion, *Zalophus californianus*.

| | Years | months | days. | |
|---|-------|--------|-------|-----------------|
| 1. ♀. Belle Vue Z. G., Manchester: alive 1.1.1918, after . | 12 | 6 | 0 | and left alive. |
| 2. London Z. G.: 11.7.1905–5.10.1918 | 13 | 2 | 24 | |
| 3. Jardin des Plantes, Paris: 11.8.1892–25.4.1906 | 13 | 8 | 14 | |
| 4. ♀. London Z. G.: 2.6.1897–12.6.1911 | 14 | 0 | 10 | |
| 5. ♀ National Zoological Park, Washington, D.C. (N. Hollister, 1923, p. 93) | 14 | 2 | 5 | |

| | Years months days. | | | |
|---|--------------------|---|---|------------------|
| 6. Philadelphia Z. G. (39th Annual Report, p. 11): died in Dec. 1910 .. | 14 | 6 | 0 | |
| 7. ♀. Brighton Aquarium: imported Oct. 1875, died May 1890 . | 14 | 6 | 0 | |
| 8. ♂. New York Aquarium: 1907 1926; "supposed to be about four years old when purchased" (C. H. Townsend, 1926, p. 218) | 19 | 0 | 0 | age c. 23 years. |

Southern Sea-Lion, *Otaria byronii*.(*Otaria jubata*, List, ed. 9. 1896, p. 97).

| | Years months days. | | | |
|--|--------------------|---|---|-------------------|
| 1. ♀. London Z. G.: 24.8.1868-26.3.1884. It had been captured in the Falkland Islands, 8.6 1868 | 15 | 7 | 2 | age c. 16 years. |
| 2. ♀. London: 20.5.1879-24.11.1896. It was believed to be about two years old when it arrived in London from the Falklands | 17 | 6 | 4 | age c. 19½ years. |

Northern Sea-Lion, *Eumetopias jubata* (*Otaria stelleri*).

| | Years months days. | | | |
|---|--------------------|---|---|------------------|
| 1. ♀. National Zool. Park, Washington, D.C. 23.10.1900-22.1.1918 (N. Hollister, 1919, pp. 70, 71) | 17 | 3 | 1 | age c. 19 years. |

Northern Sea-Bear, *Callorhinus alascanus*.

| | Years months days. | | | |
|---|--------------------|---|---|------------------|
| 1, 2 Aquarium, Washington, D.C. (C. H. Townsend, 1929). | 9 | 0 | 0 | two individuals. |

Cape Sea-Lion, *Arctocephalus pusillus*.

| | Years months days. | | | |
|---|--------------------|---|----|--|
| 1. ♀. London Z. G. 25.10.1871-17.5.1884 | 12 | 6 | 22 | |
| 2. ♀. „ 25.7.1884-14.8.1904 | 20 | 0 | 19 | |

Australian Sea-Lion, *Arctocephalus doriferus*.

| | Years months days. | | | |
|--|--------------------|---|---|-----------------|
| 1. Taronga Zool. Park, Mosman, Sydney, N.S.W. (A. S. Le Souef, in letter from Sydney of 12.5.1930) | 16 | 0 | 0 | and left alive. |

N.B.—Of the Walrus, family Odobenidae, I have no information.

Family PHOCIDÆ.

Phoca vitulina, the common Seal of North Atlantic coasts, estuaries, and islands, is kept frequently in captivity but usually only for a very few years. However, eight individuals that lived for over six years averaged 10 years 9 months, with a maximum of over 14 years. A female lived in the National Zool. Park, Washington, D.C., 12 years 1 month 18 days (N. Hollister, 1923, p. 93), and another female was in the London Z. G., 19.4.1880-31.8.1894, 14 years 4 months 12 days.

Of all the other species of Seal, the information so far collected is too scanty, or too vague, to allow of any conclusions being drawn as to the duration of life of these interesting animals, but a Grey Seal, *Halichoerus grypus*, is known to have lived for a very long time in an underground tank in the old Berlin Aquarium; it died about 1906, after, I was told, eighteen years in the Aquarium: it was a very fine beast, and looked well and happy in the autumn of 1905.

In Lincoln's Inn Fields, in the Museum of the Royal College of Surgeons, is the skull, and imperfect skeleton, of an aged Grey Seal (W. H. Flower, 1884, p. 204), from the original Hunterian collection, which was "stated to have been presented to Mr. Hunter by a Mr. Oxendon, probably the gentleman who went two years in succession to the Orkney Isles for the purpose of shooting it. This animal had been known for thirty summers to come to the same rock, and lie basking in the sun. It had a grey beard."

Order 9. CETACEA.

There is, as yet, nothing definite to record as to the longevity of Whales. From recently published statistics it is apparent that the rate of growth is more rapid than was formerly supposed, and that such enormous animals as the Blue Whale, or Sibbald's Rorqual, *Balaenoptera musculus*, and the Humpback, *Megaptera nodosa*, become sexually adult when between two or three years old.

Capt. Robert W. Gray (1929), in an interesting letter, mentions instances to show that the Greenland, or Arctic, Right Whale, *Balaena mysticetus*, lives, on "harpoon evidence," to ages of at least over twenty-four and over thirty-seven years.

Order 10. RODENTIA.

Rats, Mice, Dormice, Jerboas, and such other small rodents are very short-lived mammals, with a specific longevity of two to three years only, and a potential longevity of five to seven years.

Squirrels, Flying-Squirrels, Marmots, Beavers, and Porcupines appear to have a specific longevity of five to ten years, and a potential longevity of fifteen to twenty years.

Family PETAURISTIDAE.

Of the larger Flying-Squirrels, a male, *Petaurista alborufus*, lived in the London Z. G., 9.9.1887-5.4.1901, 13 years 6 months 26 days, a *Petaurista inornatus* lived over 11 years in the Calcutta Z. G. (Sanyal, 1892, p. 117), and a *Petaurista leucogenys* was in the London Z. G., 15.4.1874-24.9.1882, 8 years 5 months 9 days.

Of the smaller species, all that can be said now is that eight selected individuals of the American Flying-Squirrel, *Glaucomys volans* (*Sciuropterus volucella*), in the London Z. G., between 1843 and 1916, averaged a life of 5 years 1 month 25 days, the maximum being, 15.3.1910-27.3.1916, 6 years 12 days.

Family SCIURIDAE.

The North American Grey Squirrel, *Sciurus carolinensis*, is a particularly hardy and adaptable animal, but individuals seldom live to over nine years: in the Calcutta Z. G. a life of over ten years has been recorded (Sanyal, 1892, p. 116), and it is believed that one that died in the London Z. G. 26.7.1873 had been living there since 1858, at least 14 years 7 months, and possibly 15 years 1 month (P. C. Mitchell, 1911, p. 445).

Of the Californian Grey Squirrel, *Sciurus griseus griseus*, R. C. Ross (1930, pp. 76, 77) has published an account of specimens belonging to Frank G. Harriman, at Jamestown, California, one male alive at eight years and one male and two females eleven years old and still living.

A female Fox-Squirrel, *Sciurus niger* (*Sciurus capistratus*), lived in the London Z. G., 14.11.1862–3.11.1872, 9 years 11 months 19 days.

Of the Chikaree, *Sciurus hudsonicus*, the maximum for the London Z.G., 30.5.1891–3.8.1899, is 8 years 2 months 4 days. A. Brooker Klugh (1927, pp. 6-8). writing of the longevity in captivity in American of this species, says that, according to C. Macnamara, one "began to show signs of age" at six years old, and it died "in his ninth year." R. H. Hatt (1929, p. 76) states that "the record of a free, though tame, Squirrel, known well to Walton extends over a period of ten years."

An albino Palm-Squirrel, *Funambulus palmarum*, which belonged to the Hon. Walter Rothschild (now Lord Rothschild, F.R.S., V.P.Z.S.) lived in the London Z. G., 14.9.1899–12.4.1905, 5 years 6 months 28 days.

A male Malabar Giant Squirrel, *Ratufa indica*, is said to have lived for over sixteen years in the possession of the Bombay Natural History Society, and to have died in the Museum in Apollo Street, Bombay, in March 1901.

A Finlayson's Squirrel, *Callosciurus finlaysonii*, lived in the London Z. G., 27.2.1914–21.1.1923, 8 years 10 months 24 days. Two males of this species from Ko Si Chang, Gulf of Siam, both received in the Rotterdam Z. G. 18.5.1919, were both still alive there, 1.6.1930, after 11 years 12 days; these are the individuals whose periodical colour changes have been noted and figured by K. Kuiper (1929).

A male Sudan Ground-Squirrel, *Xerus rutilus*, caught on the Blue Nile 17.12.1913, died in the Giza Z. G., 13.2.1920, after 6 years 1 month 26 days in captivity. P. Pallary (1928) has published a note on a pair of Barbary Ground-Squirrels, *Xerus getulus*, living 5 years in captivity.

An Eastern Chipmunk, *Tamias striatus*, lived in the London Z. G., 8.4.1891–13.4.1898, 7 years and 5 days, and R. C. Ross (1930) mentions several individuals of the Long-eared Chipmunk, *Eutamias quadrimaculatus*, which were accidentally killed after living eight years in captivity in California.

Of the Prairie-Marmot, Prairie-Dog or Wishtonwish, *Cynomys ludovicianus*, twelve individuals can be said, from checked records, to have lived for over three years in the London Z.G. in the years 1872–1930; their average is 4 years 11 months 4 days, the maximum being, 10.7.1893–13.9.1901, 8 years 2 months 3 days, and the next longest, 22.8.1922–23.3.1930, 7 years 7 months 1 day. For the Calcutta Z. G. Sanyal (1892, p. 119) gives a record of nearly 8 years.

A Lichtenstein's Souslik, *Citellus mugosaricus*, lived in the London Z. G., 12.10.1899–1.2.1906, 7 years 1 month 19 days, and a Say's Ground-Squirrel, *Citellus grammurus*, presented to the London Z. G. 15.11.1886, died 2.10.1896, having lived there 9 years 10 months 17 days. Otis Wade (1930) has published valuable notes with reference to aestivation and hibernation in the Thirteen-lined Ground-Squirrel, *Citellus tridecemlineatus*, and other forms.

The Alpine Marmot, *Marmota marmota*, is an exceedingly interesting mammal, the question of its longevity being associated with its hibernating habits and its reputed inability to breed unless it has hibernated during the

preceding winter. If it hibernates and then reproduces its species in the following year, is its life shorter than if it keeps awake all the winter?

It must be remembered too that the question of hibernation is bound up with other factors than that of a cold temperature; one of these factors appears to be elevation above sea-level.

Fourteen examples of records of the life of the Alpine Marmot under artificial conditions in western Europe must be given in detail :—

| | | Years | months | days. | |
|-----|--|-------|--------|-------|-----------------|
| 1. | Jardin des Plantes, Paris : 21.5.1900–29.4.1906 | 5 | 11 | 8 | |
| 2. | " " " " 5.3.1913 17.2.1919 | 5 | 11 | 12 | |
| 3. | London Z. G. : 1.9.1924, living 4.11.1930 | 6 | 2 | 0 | and left alive. |
| 4. | " " " " 22.2.1813–19.6.1849 | 6 | 3 | 27 | |
| 5. | " " " " 29.11.1920–2.5.1927 | 6 | 5 | 3 | |
| 6. | Frankfort o. M. Z. G. (M. Schmidt, 1880, p. 305) | 6 | 8 | 18 | |
| 7. | " " " " " " | 6 | 9 | 20 | and left alive. |
| 8. | " " " " " " | 7 | 5 | 12 | |
| 9. | ♀. London Z. G. : 10.11.1866–15.7.1874 | 7 | 8 | 5 | |
| 10. | Hamburg Z. G. (Report for 1904, p. 10) | 7 | 10 | 6 | |
| 11. | ♂. London Z. G. : 10.1.1877–2.12.1885 | 8 | 7 | 22 | |
| 12. | " " " " 29.11.1920, living 4.11.1930 | 9 | 11 | 5 | and left alive |
| 13. | " " " " 10.1.1877 19.5.1887 | 10 | 1 | 9 | |
| 14. | " " " " 10.3.1859 1.10.1872 | 13 | 6 | 21 | |

A Woodchuck, *Marmota monax*, lived in the London Z. G., 8.7.1884–9.3.1894, 9 years 8 months 1 day. A Bobak Marmot, *Marmota bobak*, lived in England, in the care of Mrs. A. L. Butler, for 8 years (A. L. Butler, in letter of 6.8.1930). Three individuals of the Long-tailed, Himalayan or Hodgson's Marmot, *Marmota caudata*, have lived to over six years in the London Z. G., the maximum being, 4.5.1871–4.12.1877, 6 years 7 months.

Family CASTORIDÆ.

R. C. Griffith (1848) on 28.3.1848 called the attention of this Society to a Beaver having lived fourteen years in captivity, but whether this was a European or an American Beaver is not mentioned. In the London Z. G. the longevity record is held by a male European Beaver, *Castor fiber*, from the Rhone, 26.6.1893–29.3.1905, 11 years 9 months. Only two American Beavers, *Castor canadensis*, appear to have lived for over ten years in London, a male, 7.7.1886–7.8.1896, 10 years 1 month, and a female, 3.11.1869–27.12.1879, 10 years 1 month 24 days.

C. E. Johnson (1927), quoting from J. I. Benson (1924), refers to a male American Beaver which died in 1921 "when not less than seventeen years old," and to a female, which Benson sold in 1922 to the Hamburg Z. G., which was still alive there in September 1923, when she was "at least nineteen years of age."

Family MUSCARDINIDÆ.

Dormice of all species in captivity have a span of life of two to three years, and sometimes longer; thus two Fat Dormice, *Glis glis*, received in the London Z. G. 9.4.1910, lived to 2.5.1914, and 29.5.1914, 4 years 23 days and 4 years 1 month 20 days respectively, and a Garden Dormouse, *Elomys quercinus*, lived in the London Z. G., 13.4.1923–23.10.1928, 5 years 6 months 10 days. E Naundorff (1929) has written an account of two *Glis glis*, taken young,

which lived for four years in captivity and died showing signs of senile decay. A Dormouse, *Muscardinus avellanarius*, from Hertfordshire, England, has lived in the London Z. G., 29.10.1928–10.1.1931, 2 years 2 months 11 days, and the maximum for this species in captivity at Genoa, Italy, as recorded by O. de Beaux (1930) is a male, 28.2.1926–28.1.1929, 2 years 11 months.

Family MURIDAE.

Subfamily CRICETINAE.

Ten individuals of the European Hamster, *Cricetus cricetus*, in the London Z. G. between 1870 and 1926 average a life of 2 years 2 months 20 days, the maximum being, 31.7.1913–31.1.1916, 2 years 6 months.

Subfamily SIGMODONTINAE.

F. B. Sumner (1922) has shown that the White-footed Mouse, *Peromyscus maniculatus gambeli*, is long lived in captivity, seven individuals averaged 4 years 4 months 8 days, and the maximum, a female, was 5 years 8 months. For the Grasshopper Mouse, *Onychomys leucogaster fuscogriseus*, V. Bailey and C. C. Sperry (1929) record a life in captivity of nearly three years. In the London Z. G. a South American Long-tailed Mouse, *Oryzomys longicaudatus*, 8.7.1913–11.5.1916, lived 2 years 10 months 3 days, and a "Pampas Gerbil," *Reithrodon typicus*, 9.1.1913–14.6.1916, 3 years 5 months 5 days.

Subfamily MURINAE.

No certain evidence has been obtained of the longevity in a wild state of the Black Rat, *Rattus rattus*, and the Brown Rat, *Rattus norvegicus*. Mr. H. Reginald Woodward, in a letter to me of 16.2.1926, wrote that domestic rats in England live from two to three years: this is my personal experience also. The longest record I have of a male *Rattus rattus* is 2 years 11 months 15 days, and of a male *Rattus norvegicus* 3 years 1 month: females have had shorter lives.

In the London Z. G. there is no record of a *Rattus norvegicus* living to three years, but five cases in which *Rattus rattus* has lived from three to three and a half years, and also the incident of the "Australian Bush-Rats, *Haplotis arboreicola*," which were identified later as *Rattus rattus* by the late Mr. Oldfield Thomas, F.R.S., F.Z.S.; of the five "Bush-Rats" presented 23.8.1897, one is recorded to have died 6.8.1901 and one 30.10.1901, so, allowing for the time occupied in the voyage from Australia, both lived to over four years.

Of the House-Mouse, *Mus musculus*, the longest record I have is only 1 year 6 months 19 days, but of the Harvest Mouse, *Micromys minutus*, ten individuals in the London Z.G., 1896–1930, averaged 2 years, the maximum, 19.12.1896–3.8.1899, being 2 years 7½ months.

The Kusu Rats, *Arvicanthis spp.*, and the Spiny-Mice, *Acomys spp.*, appear to have greater viability than *Rattus* or *Mus*: ten Kususes average 3 years 9 months 18 days, the maximum being a Nile Rat, *Arvicanthis niloticus*, in the London Z. G., 26.4.1894–13.1.1901, 6 years 8 months 17 days: ten Spiny-Mice average 3 years 6 months 6 days, the maximum being a Hunter's Spiny-Mouse, *Acomys hunteri*, in the London Z. G., 3.5.1895–15.10.1899, 4 years 5 months 12 days. A male Golden Spiny-Mouse from Sinai, *Acomys russatus russatus*, lived in the Giza Z. G., 16.10.1910–28.12.1913, 3 years 2 months 12 days.

Two Giant Rats, *Cricetomys gambianus*, presented 30.5.1926 to the London Z. G., are still alive there, 4.11.1930, after 4 years 5 months 4 days.

From the above and from isolated notes on other genera of the Murinae, it appears that the expectation of life for a Rat or Mouse must be under two years.

Subfamily GERBILLINAE.

In all groups of Rodents which breed freely and quickly in captivity it requires great care in keeping track of individuals to obtain accurate records of longevity: this is particularly true of the Gerbils. In the Giza Z. G., through a series of years, the lives of Egyptian Rats, Mice, and Gerbils were studied to try to obtain knowledge, not only of their specific and potential longevity, but also of the conditions, favourable or unfavourable, affecting the numerical increase of individuals and the rate of immature mortality. Statistics published (S. S. Flower, 1920, pp. 27, 28) show that of Rats and Mice born at least 38 per cent. may be expected to die before reaching an age of five months.

The average length of life in the Giza Z. G., Oct. 1898–March 1924, of the twenty individual Gerbils that lived longest was 3 years 10 months 26 days. In the London Z. G., as far as can be ascertained, in the years 1882 to 1926, the average for twenty selected individuals was 3½ years. Five noteworthy records are:—

| | | Years | months | days. |
|---|---------------|----------|--------|-------|
| 1. Lesser Egyptian Gerbil, <i>Gerbillus gerbillus</i> . | Giza Z. G., | | | |
| 1.6.1908 | 12.12.1912 | 4 | 6 | 11 |
| 2. Lesser Egyptian Gerbil, <i>Gerbillus gerbillus</i> . | London Z. G., | | | |
| 31.8.1906 | 14.9.1911 | 5 | 0 | 14 |
| 3. Dormouse-tailed Jird, <i>Meriones calurus</i> , ♀. | Giza Z. G., | | | |
| 25.7.1912 | 9.1.1918 | 5 | 7 | 12 |
| 4. Sundevall's Jird, <i>Meriones tristis</i> . | Giza Z. G., | 2.6.1916 | | |
| 29.11.1920 | | 4 | 5 | 27 |
| 5. Long-fronted Jird, <i>Meriones longifrons</i> . | London Z. G., | | | |
| 29.4.1889 | 2.10.1893 | 4 | 5 | 3 |

Subfamily MICROTINAE.

M. A. C. Hinton (1926), after describing the peculiar dentition of the Voles, writes:—"The Water-Vole, *Arvicola amphibius*, like other highly specialized Microtinae, is remarkable in another way. In the oldest individual known, selected from many hundreds of recent specimens and thousands of fossils, not only were the molar teeth actively growing at the moment of death, but the skeletal development was still incomplete. This is apparent in the skull, but more obvious in the limb skeleton, in which the epiphyses are still unfused with the shafts of the long bones. Such old Water-Voles, although centenarians in comparison with the average adults of our collections, are, nevertheless, in full vigour; and, so far as actual observation is concerned, cross-examination would force us to admit that the Water-Vole and some of its relations are mammals which apparently never stop growing and never grow old."

It is unfortunate that the records of Lemmings, Voles, and Musquash in captivity are too scanty to give actual knowledge of their length of life. The most definite item of information is that on 25.10.1904 Mr. R. I. Pocock, F.R.S., presented to the London Z. G. ten Bank-Voles, *Clethrionomys glareolus* (*Arvicola pratensis*): one of these is recorded to have lived till 19.9.1909, and another till 28.9.1909, 4 years 10 months 24 days and 4 years 11 months 3 days respectively.

Family SPALACIDAE.

In the Calcutta Z. G. the Bay Bamboo-Rat, *Rhizomys badius*, has lived for at least three years (Sanyal, 1892, p. 121), and an individual in the London Z. G. lived, 14.6.1880–2.11.1883, 3 years 4 months 18 days.

Family HETEROMYIDAE.

A North American Jumping-Rat, *Dipodomys sp.*, has lived three years in New York (Bull. New York Zool. Soc. 16, p. 956, 1913), and S. E. Aldous (1930) has recorded the lives of two female Silky Pocket Mice, *Perognathus flavus*, in New Mexico. Both were full-grown when caught; one obtained in June 1925 was still alive in December 1929, three and a half years later; the other died 20.12.1928, after 4 years 11 months in captivity; after death her teeth were found to be "well worn."

Family JACULIDAE.

The Lesser Egyptian Jerboa, *Jaculus jaculus*, lives long in captivity for a mammal of its size. Thirty individuals in the Giza Z. G. had an average life of 3 years 5½ months, the maximum being, 26.5.1908–23.4.1914, 5 years 10 months 27 days. The maximum in the London Z. G., 26.10.1909–12.11.1913, is 4 years 16 days. My sister, Mrs. S. T. P. Prideaux, kept a very tame individual alive in England for 5½ years; latterly its eyesight began to fail, and it was accidentally killed by running under someone's foot 6.11.1914. In the Clifton Z. G. a Jerboa of this species is believed to have lived, 1907–1913, for over 6 years 4 months.

The Greater Egyptian Jerboa, *Jaculus orientalis*, has a much shorter average life in captivity, under two years. The maximum record for the Giza Z. G. is 4 years 4 months 27 days; in the London Z. G. one lived, 5.3.1875–15.11.1879, 4 years 8 months 10 days, and another, 11.11.1912–30.10.1917, 4 years 11 months 19 days.

Family PEDETIDAE.

A Cape Jumping Hare, *Pedetes cafer*, lived in the London Z. G., 31.3.1899–20.11.1906, 7 years 7 months 20 days.

Family HYSTRICIDAE.

Porcupines of the genus *Hystrix* often live to from eight to twelve years in zoological gardens. The following particular instances of Porcupines living to over twelve years are worth recording:—

Genus *Hystrix*.

| | | Years months days. | | | |
|----|---|--------------------|----|----|-----------------|
| 1. | <i>cristata</i> . London Z. G.: born 14.4.1894, removed 1.5.1906. | 12 | 0 | 17 | and left alive. |
| 2. | " " 5.4.1896–11.10.1898 | 12 | 6 | 6 | |
| 3. | <i>longicauda</i> . " 20.7.1868–12.1.1881 | 12 | 6 | 24 | |
| 4. | <i>cristata</i> . " 6.4.1897–26.12.1909 | 12 | 8 | 20 | |
| 5. | " from Blue Nile, –5.1911: Giza Z. G., living 31.3.1924 | 12 | 10 | 0 | and left alive. |
| 6. | <i>longicauda</i> . Calcutta Z. G. (Sanyal, 1892, p. 122) | Over 13 | 0 | 0 | |

| | | Years | months | days. | |
|-----|--|-------|--------|-------|-----------------|
| 7. | <i>cristata</i> , London Z. G., 26.1.1883-6.3.1896 . . . | 13 | 1 | 10 | |
| 8. | „ from Sudan, 12.12.1910 . Giza Z. G., living 31.3.1924 | 13 | 3 | 19 | and left alive. |
| 9. | „ ♂. London Z. G.: 25.8.1865-26.10.1879 . | 14 | 2 | 1 | |
| 10. | „ ♀. from the Blue Nile, 17.8.1909: Giza Z. G., living 31.3.1924 | 14 | 7 | 14 | and left alive. |
| 11. | <i>javanica</i> , ♂. London Z. G.: 4.10.1880-23.11.1895 | 15 | 1 | 19 | |
| 12. | <i>longicauda</i> , ♀, belonged to S. S. Flower: 14.10.1897-3.1.1913 | 15 | 2 | 19 | |
| 13. | <i>cristata</i> , ♂. London Z. G.: 12.11.1860-28.3.1876 | 15 | 4 | 16 | |
| 14. | <i>longicauda</i> , Philadelphia Z. G.: 3.10.1903-3.11.1921 (C. E. Brown, 1925, p. 266) | 18 | 1 | 1 | |
| 15. | <i>cristata</i> , ♂. London Z. G.: 25.8.1865-9.1.1886 | 20 | 4 | 14 | |

Of this last individual there is a contemporary post-mortem note, "bones useless," so presumably the animal lived on into a real state of senile decay.

The Asiatic and the African Brush-tailed Porcupines, *Atherurus macrourus* and *Atherurus africanus*, both live to over eight years in captivity, and probably to over ten years: but, owing to quite excusable differences in the records, it is impossible at present to give accurate statements of maximum durations of life for either species.

Family ERETHIZONTIDÆ.

All that can be said of the American Porcupines is that a Hairy Tree-Porcupine, *Coendou villosus*, lived in the London Z. G., 8.12.1883-22.11.1892, 8 years 11 months 14 days.

Family OCTODONTIDÆ.

Ten individuals of Cuming's Octodon, *Octodon degus*, in the London Z. G., between 1831 and 1894, averaged a life of 4 years 9 days, the maximum being, 2.4.1876-14.6.1881, 5 years 2 months 12 days.

Family CAPROMYIDÆ.

A Fournier's Hutia, *Capromys pilorides*, lived in the London Z. G., 15.7.1873-18.3.1883, 9 years 8 months 3 days.

Family MYOCASTORIDÆ.

Twenty Coypu Rats, *Myocastor coypus*, in the London Z. G. averaged a life of 4 years 8 months, the maximum being, 10.4.1897-1.9.1902, 5 years 11 months 2 days.

Family THRYONOMYIDÆ.

A Great Cane-Rat, *Thryonomys swinderianus*, presented to the London Z. G. 16.11.1928, is still alive there 11.11.1930.

So far no specimen of this handsome and interesting animal appears to have completed two and a half years in London.

Family CUNICULIDÆ.

A male Spotted Paca, *Cuniculus paca* (*Coelogenys paca*), lived in the London Z. G., 28.12.1897-19.2.1906, 8 years 1 month 21 days, and a female in the National Zool. Park, Washington, D.C., 11.4.1908-3.1.1921, 12 years 8 months 22 days (N. Hollister, 1922, p. 89).

Family DASYPROCTIDAE.

Forty-six individual Agoutis, *Dasyprocta spp.*, give an average life of just over 6 years. Ten records should be mentioned specially:—

| | Years | months | days. |
|---|---------|--------|-------|
| 1. <i>aguti</i> . Jardin des Plantes. Paris : 8.11.1891-5.3.1902 | 7 | 3 | 27 |
| 2. <i>cristata</i> . ♀. London Z. G. : 28.8.1868-31.3.1876 | 7 | 7 | 3 |
| 3. <i>punctata</i> . „ 2.7.1891-23.3.1899 | 7 | 8 | 21 |
| 4. <i>aguti</i> . Frankfort o. M. Z. G. (M. Schmidt, 1880. p. 305) | 8 | 0 | 0 |
| 5. <i>punctata</i> . London Z. G. 10.9.1883-28.10.1896 | 8 | 1 | 18 |
| 6. <i>cristata</i> . „ 2.3.1870-9.6.1878 | 8 | 3 | 7 |
| 7. <i>azarae</i> . „ 21.7.1891-9.8.1900 | 8 | 4 | 26 |
| 8. <i>aguti</i> . Jardin des Plantes Paris : 25.3.1907-31.12.1917 | 10 | 9 | 6 |
| 9. <i>punctata</i> . Calcutta Z. G. (Sanyal, 1892 p. 124) | Over 12 | 0 | 0 |
| 10. <i>mericana</i> . ♀. Nat. Zool. Park. Washington. D.C. 7.7.1910-23.8.1923 (N. Hollister, 1925. p. 94) | 13 | 1 | 21 |

Family VIZCACHIDAE.

Sixteen individuals of the Chinchilla, *Chinchilla laniger*, in the London Z. G., 1848-1894, averaged a life of 4 years 3 months 24 days, the maximum being, 6.7.1870-11.5.1877, 6 years 10 months 5 days.

It appears that the Viscacha, *Viscacia viscacia*, rarely lives over five years in captivity in Europe. The longest record for the London Z. G. that I have found is 19.4.1866-1.1.1873, 6 years 8 months 12 days.

Family CAVIIDAE.

The Guinea-Pigs, *Cavia porcellus*, in the Giza Z. G. defeated all out attempts to obtain from them statistics of longevity: all that can be said is that their average length of life was over two years. The Zoological Society of London has had more important matters to attend to than the recording of Restless Cavies's lives, so no information was available in Regent's Park. Mr. H. Reginald Woodward, in a letter of 16.2.1926, told me that the usual longevity of Guinea-Pigs in England was from two to three years, though their potential longevity is much greater.

A male long-haired Guinea-Pig born in my house at Tring 29.10.1924, died from no apparent cause or sign of senile decay 7.1.1930, at the age of 5 years 2 months 9 days. My sister, Mrs. S. P. T. Prideaux has kept many Guinea-Pigs; two individuals have lived to over six years when "they just died, with no illness, so we trust from old age." I have been told of a Guinea-Pig living to the age of thirteen, but, so far, have been unable to prove the truth of this statement.

Of wild Guinea-Pigs in captivity, the longest available record is that of a Spix's Cavy, *Cavia spixii*, in the London Z. G., 1.10.1906-3.5.1911, 5 years 7 months 2 days.

The Greater Mara, or Patagonian Cavy, *Dolichotis magellanica*, is to be seen in most European zoological gardens. The longest record for the Jardin des Plantes, Paris, appears to be, 15.3.1899-16.9.1903, 4½ years. Nine individuals in the London Z. G. average 5 years 7 months 26 days, with a maximum of, 13.8.1884-4.5.1892, 7 years 8 months 21 days: this was a male. In the Bale Z. G. a female lived, 5.6.1918-8.10.1925, 7 years 4 months 3 days.

A male Mara which died in the Belle Vue Z. G., Manchester, about 1908, was believed to have lived there for 9 years 7 months, and one alive 1.1.1925 was said to be 10 years 9 months in age.

A male lived in the Berlin Z. G., 6.12.1907–17.11.1918. 10 years 11 months 11 days (L. Heck, in a letter of 14.11.1930).

In the National Z. G., Pretoria, South Africa, the record for a Patagonian Cavy is "nearly fourteen years" (R. Bigalke, 1929, p. 300).

Family HYDROCHOERIDÆ.

Definitely dated records of the Capybara, *Hydrochoerus hydrochoeris*, are disappointing; one would have hoped that this, the largest of Rodents, would have lived longer.

| | | Years | months | days. | |
|----|---|--------|--------|-------|------------------|
| 1. | Jardin des Plantes, Paris : 14.12.1915–14.12.1921 | 6 | 0 | 0 | |
| 2. | ♂. Berlin Z. G. : 10.4.1910–15.12.1917 (L. Heck, in letter of 14.11.1930) | 7 | 8 | 5 | |
| 3. | Calcutta Z. G. (Sanyal, 1892, p. 125) | Nearly | 8 | 0 | 0 and left alive |
| 4. | London Z. G. : 12.6.1893–6.9.1901 | | 8 | 2 | 24 |
| 5. | " 18.5.1891–24.3.1900 | | 8 | 10 | 6 |

Order 11. LAGOMORPHA.

Family LEPORIDÆ.

A European Hare lived in the London Z. G., 12.10.1881–9.9.1887, 5 years 10 months 27 days. A male Blue Nile Hare, caught near Singa in May 1912, lived in the Giza Z. G. till it was accidentally killed 12.8.1917, 5 years 2½ months later. The poet, William Cowper (1731–1800) had three male Hares as pets, one of which lived for nine years, and one, after eleven years eleven months, died of "sheer old age."

Mr. H. Reginald Woodward, in a letter of 16.2.1926, told me that the life of domestic Rabbits in England extended to "just over five years." In the London Z. G. it is recorded that three domestic Rabbits, received 5.6.1876, were used as food for the animals 20.4.1882, when they would have been at least 5 years 10½ months old.

G. E. H. Barrett-Hamilton (Part 11, p. 228, 1912) mentions cases of Rabbits living to six years, to over ten years, to eleven years, and to a male over thirteen years old.

It can be said that Hares and Rabbits can live to an age of five or six years, and exceptionally to twice as long.

Order 12. PROBOSCIDEA.

Family ELEPHANTIDÆ.

Indian Elephant, *Elephas maximus* (*Elephas indicus*).

The French artillery officer General P. Armandi (1843, p. 7) puts the extreme length of life of an Elephant as 120 years. The late Mr. W. T. Blanford, F.R.S., F.Z.S. (1891, p. 446), wrote:—"An elephant is fully grown, but not fully mature, at twenty-five years of age, and individuals have been

known to live over a hundred years in captivity : in a wild state their existence probably extends to 150 years."

A statement by such a great zoologist and careful writer as Blanford cannot be passed over lightly. I much regret not to be able at present to agree with his statement. So far I have been unable to find any absolutely convincing evidence of an Elephant living to the age of 100 years, and in regard to Blanford's last sentence it appears to me that it is probable that an Elephant would live longer in captivity, carefully tended and guarded against accidents, than it would in a wild state, exposed to the many chances which terminate the careers of wild things once old age begins to affect their bodily power.

Elephants are mature at an earlier age than is commonly supposed. A pair of Asiatic Elephants that were in my charge for nearly seven years became sexually adult when, we believe, between eleven and fourteen years old, and the female gave birth to a calf when she was about fourteen to sixteen years old. The late Mr. Julius Schiott informed me that the Elephant which gave birth to a calf in the Copenhagen Z. G. 9.12.1907 was then thirteen years old.

As a "proof" of the great age to which Elephants live it has been stated in various forms that while Lord Curzon of Kedleston was Viceroy of India (1898-1905) there had died, or he had ridden on, a State Elephant of the Government of India that had taken part in State processions and functions since the time, according to the version, of Clive (1764-1767), Warren Hastings (1773-1785), or the Marquis of Wellesley (1797-1805).

Writing of the Elephants at Barrackpore, Lord Curzon (1926, 2, p. 26) states that there were no State Elephants left when he was Viceroy, and "in Lord Lansdowne's time (1888-1894) the number of the Viceroy's stud had shrunk to three animals alone, one of which, said to have been ridden by Warren Hastings, one hundred and twenty years before, was drowned while crossing the Ganges."

It should be noted that the late Lord Curzon used the qualifying word "said." If it could have been proved it can be imagined that no effort or trouble would have daunted him from making the necessary research.

Of the temple Elephants in Ceylon, Dr. F. Sarasin, F.M.Z.S., has told me that the wonderful old ages, to which they are *said* to live, rest on the word of the priests who show the animals to visitors.

In Siam some of the Royal Elephants lived in the same compound, the Wang Na, in Bangkok, as I did in the winter of 1896-1897, and later. The biggest tusker of all, the most magnificent Asiatic Elephant I have ever seen, was brought by the Chief Mahout every morning to my quarters to be inspected and fed by my wife and myself. This Elephant was said to be forty years old. I have no reason to doubt it. One day a high English official visiting Bangkok was shown the Elephant; he said it must be eighty years old; the Chief Mahout and everyone present, except myself, immediately agreed with him. This gave me an object lesson in "ageing" animals.

The available evidence as to the maximum ages of Asiatic Elephants can be stated under three headings:—

1. Evidence in India.
2. Evidence from zoological gardens in Europe, America, and Australia.
3. Evidence from dentition.

1. *Evidence in India.*

In 1882, at the request of my father, the late Sir William Flower, K.C.B., F.R.S., P.Z.S., the Government of Madras went into the question of the age

The first Indian Elephant in America was landed at New York 13.4.1796 (G. G. Goodwin, 1925) the date of its death is uncertain, 1816 or 1827 ?

Nine Asiatic Elephants have lived for over ten years in the London Z. G. :—

| | Years months days. | | | |
|--|--------------------|----|----|-------------------|
| 1. ♂. "Jack," purchased from Capt. Smith 11.5.1831, died 5.6.1847 | 16 | 0 | 24 | |
| 2. ♀, presented by King William IV. 7.8.1835, died from effects of a thunderstorm 16.7.1855. Weight 5225 lbs. (A. D. Bartlett, 1898, p. 57) | 19 | 11 | 9 | |
| 3. ♀, purchased, c. 15 months old, 19.4.1851, died 7.7.1875 | 24 | 2 | 18 | age c. 25½ years. |
| 4. ♂. "Jung Pasha" or "Jung Pershad," presented. c. 6 years old, by H.R.H. the Prince of Wales (Edward VII.) 17.5.1876. died 8.3.1896. "Height 9 ft. 10 in." | 19 | 9 | 21 | age c. 25½ years. |
| 5. ♀. "Suffa Culli," presented, c. 9 or 10 years old, by H.R.H. the Prince of Wales, 17.5.1876. Shot 2.12.1917 | 41 | 6 | 15 | age c. 51 years. |
| 6. ♂, purchased 10.4.1896, sold 6.11.1908 | 12 | 6 | 26 | and left alive. |
| 7. ♀. "Lukhi," presented 15.6.1903, sold 29.12.1923. | 20 | 6 | 14 | and left alive. |
| 8. ♀. "Nellie," presented 9.6.1906, shot 22.4.1918 | 11 | 10 | 13 | |
| 9. ♀. "Jessie," presented 5.1.1909, died 16.1.1920 | 11 | 0 | 11 | |

Other interesting records of Asiatic Elephants in Europe are :—

| | | | | |
|---|----|---|----|--------------------------|
| 10. "Topsy." Belle Vue Z. G., Manchester: died in Nov. 1898 | 15 | 4 | 0 | |
| 11. ♀. "Sally." Belle Vue Z. G., Manchester: died in June 1901 | 32 | 5 | 0 | |
| 12. ♀. "Dinah." Belle Vue Z. G., Manchester: alive 1.1.1912 | 29 | 3 | 0 | left alive. |
| 13. ♀. "Zebi." Clifton Z. G.: received, when considered to be 8 years old, 4.11.1868; died in January 1910, 'her height being approximately 10 ft. and her weight about 5 tons' | 41 | 2 | 0 | age c. 49 years. |
| 14. ♀. "Zita." Dublin Z. G.: received March 1882, shot in 1903 | 21 | 0 | 0 | Circa |
| 15. ♀. "Sandari." Dublin Z. G.: presented 17.6.1913. In the years 1924-1927 she is said to have grown in height at the rate of about one inch a year. Died 17.1.1930 | 16 | 7 | 0 | |
| 16. Jardin des Plantes, Paris: 16.11.1862-8.5.1882 | 19 | 5 | 22 | |
| 17. " " " 16.11.1862-9.12.1888 | 26 | 0 | 23 | |
| N.B. It was the two Elephants "Castor" and "Pollux," in the Jardin d'Acclimatation, Bois de Boulogne, that were killed and sold to the butchers for 27,000 francs during the siege of Paris in 1870, not the Elephants in the Jardin des Plantes, as is sometimes stated. | | | | |
| 18. ♂. "Williams." Marseilles Z. G.: died 25.3.1906. | ? | 0 | 0 | age said to be 32 years. |
| 19. ♀. "Jacqueline." Antwerp Z. G.: arrived, from Akyab, 26.9.1852, died 31.1.1880 | 27 | 4 | 5 | |
| 20. ♂, from Sumatra. Rotterdam Z. G.: received 1902; killed on account of his dangerous bad temper in December 1912 | 10 | 0 | 0 | age c. 14 years. |
| 21. ♀. Hague Z. G.: received in 1875 when very small; by 1900 had become excessively savage; died 24.5.1908 | 27 | 0 | 0 | Circa |

Years months days.

22. ♂. "Hathi," now "Harry." Detached from Indian Commissariat Transport 21.12.1898, when he was said to be between 7 and 8 years old. In Giza Z. G., Egypt, from 11.1.1899-21.11.1904, when he left for Hamburg, and on 8.6.1905 arrived in the Berlin Z. G., where I visited him in 1905, and where I saw him last in July 1929 (S. S. Flower, 1930, p. 662). Living 14.11.1930 31 10 23 age c. 39 or 40 years.
23. ♂. "Theodor," from Ceylon. Presented, when supposed to be two years old, 12.9.1863, to London Z. G. Sold in 1873 to Breslau Z. G. for £450. Arrived Breslau 14.9.1873, died there 28.11.1888 25 2 16 age c. 27 years.
24. ♀. "Bella." Cologne Z. G.: received, when said to be four years old, 26.4.1872. Died between May 1910 and Jan. 1911 At least 38 0 0 age 42 or 43 years.
25. ♀. "Lilli." Dresden Z. G.: received 6.7.1863. Died 7.6.1911, from lung trouble 47 11 1 age c. 50 or 51 years.
Her death was probably hastened by the accident that towards the end of 1910 the only keeper that she tolerated fell very ill at a time when the doors of the elephant-house had been opened during a spell of mild weather. The old Elephant allowed no one to shut the doors, so they had to be left open day and night, and she caught a fatal cold.
26. ♀. "Fanny." Frankfort o. M. Z. G.: 26.6.1889-3.2.1917 27 7 7 age c. 33 or 34 years.
27. ♂. "Anton I." Hamburg Z. G.: received, when supposed to be two or three years old, 24.7.1871: died 26.10.1907 36 3 2 age 38 or 40 years.
To the last "Anton" had very magnificent long tusks. In height he was said to be 2.70 metres (8 feet 10 inches).
28. ♀. "Vali." Hamburg Z. G.: received, when said to be between three and five years old, 31.10.1881. In 1907 her height was reckoned as 2.58 metres (8 feet 5½ inches). Died 20.9.1916 34 10 20 age at least 38 years.
29. ♂. "Marly." Hanover Z. G.: received 1868 or 1869?; died in 1904 36 0 0 age said to be c. 70 [years.]
30. ♀. "August." Munster i. W. Z. G.: received, when said to be about 8 years old, 18.6.1899. I saw her 29.5.1930, looking very fat and well. 30 11 11 age c. 39 years, and [left alive.]
31. ♀. "Kumbuk." Caught, when quite young, in Ceylon in June 1885. Arrived in Bâle Z. G. 30.4.1886, died 18.8.1917 31 3 18 age 32 years 2 months.
32. ♂. "Chang." Copenhagen Z. G.: received, when supposed to be 5 or 6 years old, from Siam, 18.11.1878. Died 22.12.1918. 40 1 4 age 45 or 46 years.
33. ♀. "Ellen." Copenhagen Z. G.: received, when about two years old, from Siam, 1896. Shot 9.10.1929 32 9 9 age c. 34 or 35 years.
34. ♂. "Kaspar." Born in Copenhagen Z. G. 9.12.1907 (by "Chang" out of "Ellen"), sold to Hanover Z. G. in 1912, and about 1920 sent from Hanover to the Jardin d'Acclimatation, Paris, where in 1927 he became so bad tempered that he had to be killed. Nearly 20 0 0

Twenty-two of the above thirty-four Elephants I have known personally, or at any rate seen alive. Of the following ten Elephants I have no first-hand knowledge.

Asiatic Elephants in North America.

| | | Years months days. | | | |
|--------|---|--------------------|---|----|-------------------------------|
| 35. ♂. | "Dunk." National Zool. Park, Washington, D.C.: received 20.4.1891, "was then about 25 years old"; died 1917, "over 50 years of age" (N. Hollister, 1918, p. 75.) . . . Circa | 26 | 0 | 0 | age c. 51 years. |
| 36. ♀. | "Alice." New York (Bronx) Zool. Park: received in Sept. 1908, living 17.12.1930 | 22 | 3 | 0 | [years old. said to be now 37 |
| 37. ♂. | "Gunda." New York (Bronx) Zool. Park: received 2.7.1904, destroyed in June 1915. Circa | 11 | 0 | 0 | |
| 38. ♂. | A gift from the King of Oude in 1871 to the King of Italy; it was then 3 years old and 5 feet high. After the death of King Victor Emmanuel, 9.1.1878, the animal was sold to Carl Hagenbeck of Hamburg, who in 1881 sold it to Mr. Adam Forepaugh of Philadelphia, who, 1.1.1889, presented it to the Central Park Menagerie, New York. It was then 9 feet high and had tusks 4 feet 2 inches in length (W. A. Conklin, 1889, p. 4). It weighed, 3.6.1890, 8,800 lbs., and was still growing (W. A. Conklin, 1891) Circa | 22 | 0 | 0 | and left alive. |
| 39. ♀. | "Empress." Philadelphia Z. G.: received when "quite young," 1.11.1876; died 8.7.1914. "She was not known to have lain down voluntarily during the last five years of her life" (Phil. 43rd Ann. Rep. 1915, p. 18) . . . | 37 | 8 | 7 | in Philadelphia. |
| 40. ♂. | "Bolívar." Philadelphia Z. G.: 25.12.1888-31.7.1908. "Weight 12,000 pounds" . . . | 19 | 7 | 6 | in Philadelphia. |
| 41. ♀. | "Lizzie." Philadelphia Z. G.: received 16.5.1902, living 1.7.1925 (C. E. Brown, 1925, p. 266). . . . | 23 | 1 | 15 | and left alive. |

Asiatic Elephants in Australia.

| | | | | | |
|--------|--|----|---|----|-----------------|
| 42. ♀. | "Miss Siam." Adelaide Z. G.: 1884-1904 (26th Annual Report, 1903-1904, p. 8). Circa | 20 | 0 | 0 | in Adelaide. |
| 43. ♀. | "Ranee." Melbourne Z. G.: died 18.12.1903; she was said to have lived for . . . | 21 | 0 | 0 | in Melbourne. |
| 44. ♀. | "Jessie." Sydney Z. G.: "arrived in Sydney in 1882 and is still doing remarkably well. Still doing the regulation amount of work" (A. S. Le Souef, in letter, 12.5.1930). At least | 46 | 4 | 12 | and left alive. |

From these records of Asiatic Elephants outside India that have lived longest in their respective new homes we find that they have an average life of a little over twenty-eight years.

Fourteen males average 26 years 5 months and twenty-six females average 29 years 11 months, so that there is probably little difference in the potential life of the sexes; but only one male has reached forty years, and only two are claimed to be fifty years old, or older. On the other hand, at least five females are known to have exceeded forty years, and "Zebi" of Clifton, "Lilli" of Dresden, and "Suffa Culli" of London reached ages of approximately fifty years.

3. Evidence from Dentition.

Mr. R. I. Pocock, F.R.S., F.Z.S. (1917, p. 871), writing of the female Indian Elephant "Suffa Culli" (*vide supra*, p. 193), says "the probability is she would have succumbed under the most favourable circumstances when she was about sixty. Hence it is not surprising that she looked like an old animal when she was fifty." "In view of the above-mentioned facts and calculations, it appears to me to be certain that even seventy years is a liberal estimate for the life of Indian Elephants in captivity, unless they can be kept alive on soft food after their teeth are gone. That is quite possible; but it would not apply to wild elephants. In the case of tame elephants it is known that tooth troubles sometimes arise on account of the teeth not wearing away sufficiently quickly to make room for their successors. The teeth, that is to say, do not wear down so fast as under natural conditions, because the food is of a softer quality. Hence the last grinder of a wild elephant will tend to become functionless at a quicker rate than in the case of a tame animal, and the duration of life will be shorter rather than longer."

Pocock (1918, p. 303) draws particular attention to the state of wear of the last molar tooth of "Suffa Culli." "Since this tooth comes into use in about the 40th year and had lost by wear more than one-third of its laminae in ten years," Pocock concluded "that the animal would have been toothless and would have come to the end of her time before she was seventy."

African Elephant, *Elephas africanus*.

African Elephants are far rarer in northern menageries than Asiatic Elephants. Mr. A. S. Le Souef, in a letter from Sydney, 12.5.1930, writes: "No Australian zoo. has ever possessed an African Elephant, but one was in our gardens for some months, en route to Honolulu, where it is still I think."

The twelve oldest African Elephants about which I have been able to obtain definite information have an average length of life of 24 years 3 months; these consisted of five males with an average of about 21 years 3 months and seven females with an average of 26 years 5 months. The absolute maximum is, a female, about thirty-six years old.

The five African Elephants that have lived longest in the London Z. G. are:—

| | | Years months days. | | | |
|-------|---|--------------------|---|----|-------------|
| 1. ♂. | "Jumbo." Received, in exchange, when supposed to be about four years old, 26.6.1865. Removed 22.3.1882, <i>vide infra</i> | 16 | 8 | 26 | left alive. |
| 2. ♀. | "Alice." Purchased, when very young, 9.9.1865. Removed 23.1.1886, <i>vide infra</i> | 20 | 4 | 14 | left alive. |
| 3. ♂. | "Jingo." Purchased, when young, 8.7.1882. Removed 4.3.1903, <i>vide infra</i> | 20 | 7 | 26 | left alive. |
| 4. ♂. | "Gwold." From Abyssinia: deposited, when young, by H.M. Queen Victoria, 21.8.1884; died 15.1.1893 | 8 | 4 | 24 | |
| 5. ♂. | "Johnny." From Eritrea or Abyssinia: purchased, for £275, 21.5.1901; died 4.2.1915 | 13 | 8 | 13 | |

"Jumbo" came to London from the Jardin des Plantes, Paris, when his height was said to have been 4 feet. He was sold 18.2.1882, for £2000, to Messrs. Barnum, Bailey, & Hutchinson of New York, and was removed from Regent's Park, 22.3.1882, and shipped the same day on S.S. 'Assyrian Monarch.' He arrived in New York 9.4.1882, and is said to have been killed by accident on a North American railway in September 1885, when he would have been 24 or 24½ years of age.

For dimensions of "Jumbo" and other Elephants, see P.Z.S. 1865, p. 676, and A. D. Bartlett, 1898, pp. 45, 46, 51, 60, & 61.

"Alice" was from the Eastern Sudan, collected by Signor Casanova. From Austria she came to London. The Zoological Society purchased her from Mr. C. Rice, together with a Hornbill, a Crow, a Guinea-fowl, and six Finches, for £550, 9.9.1865. Her height was then only $3\frac{1}{2}$ feet. She was sold 23.1.1886, for £200, to Messrs. Barnum & Co. of New York. I should like to know what her subsequent history was.

"Jingo" was purchased from Herr Carl Hagenbeck for £300 when in height about 4 feet. He was sold, 4.3.1903, for £200, to Mr. F. Bostock. "Jingo's" ultimate fate is said to have been "drowned at sea."

Noteworthy records of six other African Elephants in Europe are :—

| | | Years months days. | | | |
|-------|--|--------------------|----|----|-----------------|
| 1. ♀. | Frankfort o. M. Z. G. received 1.7.1907; sent away in exchange 21.2.1922 | 14 | 6 | 20 | and left alive. |
| 2. ♂. | "Saib." Jardin des Plantes, Paris received 8.4.1883, died 30.1.1907 | 23 | 9 | 22 | |
| 3. ♀. | Rotterdam Z. G. purchased 25.5.1874, died 25.3.1903. | 28 | 10 | 0 | |
| 4. ♀. | "Lieschen." Hamburg Z. G.: presented in 1886 by C. Woerman and Consul E. Schulze, died 11.1.1916 (H. A. Hans Bungartz, in letter of 20.12.1930). | at least | | | |
| | | 29 | 0 | 11 | |
| 5. ♀. | "Chevrette." Jardin des Plantes, Paris presented 26.5.1825 by Mohamed Ali Pasha, died 1.2.1855 | 29 | 8 | 5 | |
| 6. ♀. | Berlin Z. G. 17.9.1888 2.2.1924 (L. Heck, in letter of 14.11.1930) | 35 | 4 | 16 | |

Personally I have brought nine African Elephants alive out of the Sudan and trained them myself: one of these, "Karkoj," a female, caught on the Blue Nile about the middle of May 1905 (height at the shoulder $3\frac{1}{2}$ feet, 3.7.1905), arrived in the Giza Z. G. 10.8.1905, where she lives still, 1.11.1930. Another, "Teddy," a male, also from the Blue Nile (height *circa* 4 feet 1 inch, 6.10.1906), arrived in the Giza Z. G. 25.12.1906, left for Europe 13.4.1907, and reached New York in June 1907. In January 1929 his height was said to be 10 feet $7\frac{1}{2}$ inches. Dr. R. L. Ditmars writes, 17.12.1930, that this Elephant, now called "Khartoum," is still alive in New York, and considered to be 28 years old.

Order 13. HYRACOIDEA.

Family PROCAVIAE.

The maximum recorded length of life for a Hyrax in the London Z. G. is that of a female Cape Hyrax, *Procavia capensis*, 2.6.1911–22.8.1917, 6 years 2 months 20 days.

In the Giza Z. G. the Cirogrille, or Wabur, *Procavia syriaca*, lived better than Hyrax brought from South Africa or caught in eastern Egypt; but still, although they appeared to flourish and bred freely (even to the third generation), they never lived long. The average of the ten individuals that lived longest was only 4 years 11 months 2 days. A male lived longest, born 15.3.1916, died 6.8.1923, 7 years 4 months 21 days. The record for a female, born 27.3.1917, died 13.8.1923, was 6 years 4 months 16 days.

Order 14. PERISSODACTYLA.

All large and long-lived animals, the members of the Horse and Rhinoceros families frequently live to over twenty years, and may attain to fifty. Of the Tapirs we know less; their corresponding ages may be put at fifteen and thirty years.

Family EQUIDAE.

Equine animals, for the purpose of this paper, fall into two groups—one consisting of the domestic Horse and Ass, the other of all the wild forms of Horse, Ass, and Zebra.

Now domestic animals, such as Cow, Sheep, and Swine, have in most cases an artificial limit set to their life-span, when their value, as producers of milk, wool, and piglets, is overshadowed, in their owners' opinion, by their value in the form of beef, mutton, and pork; whereas with the Horse and Ass their value as transporters of man and his goods is so far greater than their dead value that their owners keep them alive and going, in cases, to their uttermost limit.

Domestic Horses have been reported to live to 50 and 60, and Donkeys to 40 or 50 years. The longest records for wild Horses, Asses, and Zebras are only 22 to 28 years. It must be remembered that one group comprises millions of individuals, the other only some few dozens that have happened to be in private hands or menageries. There is no proof that once in a way a Wild Ass or Zebra, if suitably cared for, might not live to a really wonderful old age.

The Domestic Horse, *Equus caballus*.

The literature on the subject of the life of Horses is too great to be included in this paper. A summary, from notes collected and enquiries made, will only be given.

At what ages Horses are at their best must remain a matter of opinion, so much depending on the circumstances of breed, climate, and the nature of the work required. Horses of from eight to fifteen years old have been found most enduring in long campaigns. Some twenty-year-old cavalry chargers are claimed to have gone through the whole war in Europe, 1914-1918, without distress.

If given a fair chance it is not unusual for Horses to attain to twenty-five years, at which age a stallion may still be a good sire, a mare produce a foal, and a gelding make fine displays in jumping competitions. Pensioned race-horses and favourite old chargers very seldom live beyond thirty years; but at least one thoroughbred mare lived (1837-1870) to about thirty-three years, and a half-bred horse to about thirty-five years.

E. Oustalet (1900, pp. 378, 379) mentions two stallions, one being in an Irish stud, as being vigorous at thirty-three years of age.

Edwards Crisp (1860, p. 177) writes: "I know of an instance of a Suffolk cart-mare that bore a foal when forty-two years of age."

To read the many accounts of Horses that have lived to ages of between forty and fifty years, and a few to even sixty years, gives the impression that Ponies and coarse-bred Horses live far longer than thoroughbreds. I do not consider this to be true, apart from the fact that the actual date of birth of a non-pedigree animal is very difficult, and usually entirely impossible, to prove after a long lapse of years; it must be remembered that the actual number

of individuals of ordinary Horses is so very much greater than the number of blood Horses that it is not surprising that now and again one Horse *among millions of Horses* may live to a surprising old age.

Lord Rothschild, F.R.S., V.P.Z.S., told me, 21.9.1919, that he knew of a Pony that had lived in France for fifty-four years, and that he was satisfied as to the authenticity of the facts.

The oldest age claimed for a Horse, a Manchester Canal Horse which died 27.11.1822, is sixty-two years.

The Zoological Society of London has owned many horses; the longest record appears to be that of a Shetland Pony, 1829–11.1.1852, a little over twenty-two years, but we do not know its age on arrival, as is also the case with a Pony mare, imported from Java, which arrived in the Rotterdam Z. G. 27.1.1896, which had to be killed, 23.7.1924, after 28 years 5 months 26 days.

Mongolian Wild Horse, *Equus caballus przewalskii*.

Any facts concerning the longevity of General Przewalski's Horse are of interest as probably giving an idea of the length of life of an original, or "unimproved," Horse, as apart from the domestic races of civilized man.

From the zoological gardens of London, Manchester, New York, and Philadelphia we know that in England and in the United States these horses live, at any rate, from eleven to sixteen years. And a male presented by the Duke of Bedford to the Adelaide Z. G., which arrived there 19.2.1910, is still alive 22.10.1930, after 20 years 8 months 3 days in Australia.

The records in the Jardin des Plantes, Paris, must be given in detail. Even from this small number of individuals it may be inferred that the full natural life of a stallion or mare is somewhere near twenty-eight years: the average, of course, would be much less.

Przewalski's Horse in Paris:—

| | Years | months | days. | |
|--|-------|--------|-------|--------------------------|
| 1. ♂, 3.4.1902–15.1.1929 | 26 | 9 | 12 | Probable age 27 years 10 |
| 2. ♀, born 12.6.1909, died 19.1.1929 | 19 | 7 | 7 | [months. |
| 3. ♀, presented by the Duchess of Bedford 6.7.1906, living 17.12.1930 | 24 | 5 | 11 | Probable age 28 years. |
| 4. ♂, born 4.5.1914, living 17.12.1930 | 16 | 7 | 13 | |
| 5. ♀, born 25.4.1916, „ „ | 14 | 7 | 23 | |
| 6. ♀, born 15.5.1925, „ „ | 5 | 7 | 2 | |

Monsieur V. Parvulescu (1929) has published some measurements and a full description of the appearance and habits of these Horses in Paris, and states that the first importation of this animal by the late Herr Carl Hagenbeck arrived in Hamburg 27.10.1901. The male, 1, was born in Asia probably in the spring of 1901; the female, 3, was born in Europe probably in December 1902.

Asiatic Wild Asses.

Information from London, Paris, Berlin (E. Schwarz, 1929, p. 90), Vienna (O. Antonius, 1928, pp. 19, 20), and Philadelphia (C. E. Brown, in letter of 21.3.1930) show 23 individual Asiatic Wild Asses that averaged a life of just over 15½ years, that both males and females may live to 22 years, and that in zoological gardens the expectation of life for a female is somewhat longer than that for a male.

A female Kiang, *Equus kiang* (*Equus hemionus*), deposited in the London Z. G. by Major W. E. Hay 6.10.1859, and presented 22.10.1859, lived till 4.2.1878, 18 years 3 months 28 days, and a male presented 6.8.1908 is still alive, 3.11.1930, after 22 years 2 months 27 days. In the Jardin des Plantes, Paris, the longest record for a Kiang is of one born 8.6.1902, which died 25.5.1927, after 24 years 11 months 19 days.

A female Indian Wild Ass, *Equus indicus*, received from Cutch, at the London Z. G., 23.12.1873, when apparently adult, died 2.8.1889, after 15 years 7 months 9 days in London.

The Hemippe, or Syrian Wild Ass, *Equus hemippus*, is, in bodily stature, the smallest form of the group. A male born in the London Z. G. 12.5.1869 died 24.4.1884, 14 years 11 months 12 days. In the Schönbrunn Menagerie a male, received in 1911, when probably two, but at most three, years old, was still alive 30.4.1928, when at least about 18 years old. A female received at Schönbrunn 29.1.1857 died there 14.12.1879 (not 28.11.1892, as has been stated), after 22 years 10 months 15 days, and another female lived in the Menagerie from 1869 to 1892, so also for a period of over 22 years.

A female Onager, or Persian Wild Ass, *Equus onager*, was in the London Z. G. 11.3.1859–21.6.1877, 18 years 3 months 10 days; another female lived in the Berlin Z. G., 18.6.1893–6.1.1914, 20 years 6 months 18 days, and yet another female, born in the Philadelphia Z. G. 27.5.1902, died there 19.11.1926, after 24 years 5 months 22 days.

Zebras and Quaggas.

A male Grévy's Zebra, *Equus grevyi*, was in the National Zoological Park, Washington, D.C., from 24.11.1904 to 4.12.1919 (N. Hollister, 1921, p. 80), 15 years 10 days.

The Mountain Zebra, *Equus zebra*, lives longer in zoological gardens. A male received in London 2.6.1911 was sold 18.3.1929, thus leaving alive after 17 years 9 months 16 days. A female was in London, 14.8.1907–19.5.1930, 22 years 9 months 5 days. A female in the Jardin des Plantes, Paris, 19.1.1894–5.9.1919, lived there 25 years 7 months 16 days.

The true Quagga, *Equus quagga*, is now extinct. Only four records of individuals that have lived in zoological gardens have been found so far. These are :—

| | Years | months | days. |
|--|-------|--------|-------|
| 1. London: purchased from Mr. Thomson 25.11.1831, died 18.7.1834 | 2 | 7 | 23 |
| 2. ♀. London: deposited by Mr. Jamrach 5.3.1851, purchased from him 15.3.1851, died 15.7.1872 (not 7.7.1872, as has been stated) | 21 | 4 | 10 |
| 3. ♂. London: presented by Sir George Grey, K.C.B., 4.9.1858, died 10.6.1864 | 5 | 9 | 6 |
| 4. Amsterdam: purchased 9.5.1867, died 12.8.1883 (C. Kerbert, 1904) | 16 | 3 | 3 |

Burchell's Zebra, *Equus burchellii*, with its local forms, Chapman's Zebra and Grant's (or Boehm's) Zebra, frequently lives to over twelve years, and has been known to reach an age of between twenty-eight and twenty-nine years. In zoological gardens males in average age are surpassed by females.

A male, 1895 ?–11.7.1908, and a female, received in 1913, living in 1928, have lived to about fifteen years in the Schönbrunn Menagerie, Vienna. Another female, purchased from the Kreuzberg Menagerie 14.6.1881, died at Schönbrunn 27.4.1916, after 14 years 10 months 13 days, when she was believed to be 28 years old (O. Antonius, 1928, pp. 165, 169).

A Grant's Zebra received in the National Zoological Park, Washington, D.C., in 1909 died in 1925 (W. M. Mann, 1925, p. 90), so was at least 15 years old. A female Grant's Zebra presented to the Nouzha Z. G., Alexandria, Egypt, shortly before 7.2.1908 was still alive there 10.5.1922, when in her fifteenth year. A Burchell's Zebra in the Frankfort o. M. Z. G. was living after 15 years 7 months 19 days (M. Schmidt, 1880, p. 306). A female Grant's Zebra born in the Giza Z. G. 26.5.1908 was still alive there when I left, 1.4.1924, after 15 years 10 months 6 days. A Zebra has lived 17 years in the Pretoria Z. G., South Africa (R. Bigalke, 1929, p. 299). A female Zebra living in the Belle Vue Z. G., Manchester, in 1908, was stated to be at least 17½ years old. The record for a Chapman's Zebra in the Jardin des Plantes, Paris, 25.4.1896–31.3.1915, is 18 years 11 months 6 days. A female Chapman's Zebra seen in the Clifton Z. G., 22.9.1913, had been there, I was told, for 22 years.

In the London Z. G. a Burchell's Zebra, born 17.7.1831, died 15.21.1847, 16 years 4 months 28 days, and, in later times, a female purchased 10.3.1893, lived till 31.12.1906, 13 years 9 months 21 days. W. B. Tegetmeier (1869, p. 468) wrote of a male Zebra as being still alive, in June 1869, in the London Z. G., that had been "purchased in 1850," and an animal that died 31.10.1874 was said to have been "purchased in 1850." If this was so it would record a male Zebra of nearly 24 years old, but in the Society's Daily Occurrence Book for 1850 there is *no Zebra entry*.

The oldest authenticated Zebra, as far as I know, was a female Chapman's in the Bâle Z. G., 11.7.1891–5.9.1919, 28 years 1 month 24 days.

Donkeys.

Here there are two things to consider: first, the life-span of the domestic Donkey, *Equus asinus*: second, that of the real Wild Ass of Nubia, *Equus asinus africanus*. In both the average life of the male appears to be shorter than that of the female.

Imported African Donkeys of both sexes have lived to over nineteen years in the London Z. G.: a male, 30.4.1897–8.6.1916, 19 years 1 month 8 days; a female, 26.5.1881–16.9.1900, 19 years 3 months 22 days. Mr. A. T. Lloyd told me, 9.9.1918, of a Donkey in England that lived to the age of 37. One of 46 years has been reported (G. Mackenzie-Ashton, 1906, p. 852), and the late Mr. R. Lydekker, F.R.S. F.Z.S., told me, on the authority of Mr. F. W. Frohawk, that once "a white Donkey lived for over fifty years."

Four instances of the life of *Equus asinus africanus* are:—

| | Years months days. | | | |
|--|--------------------|---|---|-----------------|
| 1. ♀. "Nora." Caught near Goz Regeb on the Atbara in February 1906, kept in the Khartoum Z. G. from about 1.3.1906 to 15.12.1906. Arrived in Giza Z. G. 25.12.1906, where she had to be shot, 20.10.1921 | 15 | 8 | 0 | |
| 2. ♀. Frankfort o. M. Z. G.: born 30.4.1895, died 1.6.1917.. | 22 | 1 | 2 | |
| 3. ♀. Schönbrunn: presented 1889, sent to Buda Pest Z. G. 1906 (O. Antonius, 1929, p. 289) | At least 16 | 0 | 9 | and left alive. |
| 4. ♂. Schönbrunn: born 1.11.1894, died in 1917 (O. Antonius, 1929, p. 289) | At least 22 | 2 | 0 | |

Equine Hybrids, or Mules.

Seven interesting examples should be mentioned in particular :—

| | Years | months | days. | |
|---|-------|--------|-------|-----------------|
| 1, 2. London Z. G.: both presented 1.10.1830 by King William IV. One said to have been bred between Mountain Zebra and Donkey, the other between Burchell's Zebra and Donkey. One died 10.3.1840. | 9 | 5 | 9 | |
| „ „ 8.2.1847. | 16 | 5 | 7 | |
| 3. ♂, gelding. Bred in South Africa between male Zebra and pony mare. London Z. G.: presented 19.7.1902 by King Edward VII., died 11.7.1918 | 15 | 11 | 22 | |
| 4. <i>Equus asinus</i> ♂ × <i>Equus zebra</i> ♀. In France (R. I. Pocock, 1911, p. 990) | 14 | 0 | 0 | |
| 5. ♀. Jardin des Plantes, Paris: <i>Equus chapmanni</i> ♂ × <i>Equus zebra</i> ♀, born 2.5.1903, living 18.5.1930 | 27 | 0 | 16 | and left alive. |
| 6. ♀. Jardin des Plantes, Paris: <i>Equus kiang</i> ♂ × <i>Equus burchellii</i> ♀, born 6.6.1875, died 8.10.1907 | 32 | 4 | 2 | |
| 7. ♀. Jardin des Plantes, Paris: <i>Equus kiang</i> ♂ × <i>Equus caballus</i> ♀, "Hémione hybridé de Jument de Tarbes," born 14.5.1869, died 23.2.1906 | 36 | 9 | 9 | |

Family RHINOCEROTIDAE.

No explanation can be offered as to why Rhinoceroses are so difficult to keep alive in captivity, or why no menagerie has yet succeeded in establishing a "breeding pair," as is done so often with Giraffes and Hippopotamuses. It might be imagined that a Rhinoceros would be an easier animal to keep in a northern zoological garden than either a Giraffe or a Hippopotamus.

Though most Rhinoceroses lead, in captivity, short lives of less than ten years, there is no doubt that these animals have great potential longevity, as is proved by those examples that have lived to thirty, and even to over forty years. Actually twenty-seven selected individuals show an average life of almost twenty-two years. The numbers are too small to form a definite idea of the relative lengths of life of the sexes; as far as they go they point to equality.

The following table contains particulars concerning the four species of Rhinoceroses, that are seen, from time to time, in menageries :—

Great Indian Rhinoceros, *Rhinoceros unicornis*.

| | Years | months | days. | |
|--|-------|--------|-------|------------------|
| 1. ♂. London Z. G.: purchased, when said to be about four years old, 24.5.1834; died 19.9.1849 | 15 | 3 | 25 | age c. 19 years. |
| 2. ♂. London Z. G.: presented 9.6.1906, died 4.1.1924 | 17 | 6 | 25 | |
| 3. Trivandrum Z. G.: presumably of this species, but not definitely stated; received in March 1878, died 16.6.1900 (H. S. Ferguson, 1899-1900, p. 18). | | | | |
| At least | 22 | 2 | 0 | |
| 4. ♀. London Z. G.: purchased 17.7.1850, died 14.12.1873. | 23 | 4 | 27 | |
| 5. Adelaide Z. G. (29th Annual Report, 1906-1907, p. 10)... | 25 | 0 | 0 | |
| 6. Jardin des Plantes, Paris: early in 19th century (E. Oustalet, 1900, pp. 378, 379) | 25 | 0 | 0 | |
| 7. ♂. "Tom." London Z. G.: presented 25.12.1886, died 30.12.1911 | 25 | 0 | 5 | |
| 8. Philadelphia Z. G.: 13.3.1875-3.1.1901 (C. E. Brown, 1925, p. 266) | 25 | 9 | 20 | |

| | Years | months | days. |
|---|-------|--------|-------|
| 9. Hamburg Z. G.: purchased in 1871 for £650, killed 12.6.1900 on account of a wound on its head. | | | |
| At least | 28 | 5 | 12 |
| 10. ♂. Belle Vue Z. G., Manchester: purchased 20.6.1876, died during 1904 At least | 28 | 6 | 10 |
| 11. Kept in Katmandoo (B. H. Hodgson, 1834, p. 98) | 35 | 0 | 0 |
| 12. Berlin Z. G.: received 1872, living in 1908 | 36 | 0 | 0 |
| 13. ♂. Antwerp Z. G.: died 7.9.1898 Circa | 40 | 0 | 0 |
| 14. ♂. "Jim." London Z. G.: presented 25.7.1864, died 6.12.1904 | 40 | 4 | 11 |
| 15. Kept in Bengal (Sanyal, 1892, p. 131) Circa | 47 | 0 | 0 |

Sondaic Rhinoceros, *Rhinoceros sondaicus*.

| | Years | months | days. |
|--|-------|--------|-------|
| 1. ♂. London Z. G.: purchased 7.3.1874, died 23.1.1885 | 10 | 10 | 16 |
| 2. Calcutta Z. G. (Sanyal, 1892, p. 131) Over | 14 | 0 | 0 |

Asiatic Two-horned Rhinoceros, *Rhinoceros sumatrensis*.

| | Years | months | days. |
|---|-------|--------|--------------------|
| 1. <i>lasiotis</i> . Calcutta Z. G. (Sanyal, 1872, p. 132) Circa | 10 | 0 | 0 |
| 2. ♀. Madras Z. G. (S. S. Flower, 1914, p. 73) | 14 | 0 | 0 and left alive. |
| 3. ♂, <i>lasiotis</i> . London Z. G.: 27.4.1886 22.11.1910 | 24 | 6 | 25 |
| 4. ♀. "Begum." Type of <i>lasiotis</i> . Captured in January 1868, sixteen hours' march south of Chittagong. She was then considered to be "adult" or "at least two years old." She arrived London Z. G. 14.2.1872, and died 31.8.1900, after 28 years 6 months 16 days there | 32 | 7 | 0 age c. 35 years. |

Black Rhinoceros, *Rhinoceros bicornis*.

| | Years | months | days. |
|--|-------|--------|---------------------|
| 1. ♂. London Z. G.: presented 19.5.1911, died 20.7.1924 | 13 | 2 | 1 |
| 2. ♂. Obtained, when quite young, 12.2.1868, near Kassala, in the eastern Sudan, by Signor Casanova. London Z. G.: purchased 11.9.1868, died 12.4.1891 | 22 | 7 | 1 age c. 23½ years. |

Family TAPIRIDÆ.

The majority of Tapirs live less than six years in captivity; eighteen individuals who have survived for over seven years give an average of 15 years 1 month 10 days. Their potential longevity is at least thirty years. Females may be expected to live rather longer than males.

Both the Malay Tapir, *Tapirus indicus*, and the Brazilian Tapir, *Tapirus terrestris* (*Tapirus americanus*), will breed and rear their young with success in Europe.

A Tapir, but of what species is not stated, once lived for twenty-three years in the Trivandrum Z. G. (H. S. Ferguson, 1900-1901, p. 17).

The longest records for Malay Tapirs in the London Z. G. are of a pair purchased 22.6.1912; the male died 9.1.1922, 9 years 6 months 17 days; the female died 8.9.1923, after 11 years 2 months 16 days.

Seven records of the Brazilian Tapir living to over fifteen years:—

| | Years | months | days. |
|--|-------|--------|-------|
| 1. ♂. London Z. G.: presented 1.5.1884, died 1.1.1900 | 15 | 8 | 0 |
| 2. ♂. National Zool. Park, Washington, D.C., 19.5.1899-17.9.1917 (N. Hollister, 1919, p. 71) | 18 | 3 | 28 |

| | | Years months days. | | | |
|---|---|--------------------|---|----|------------------------|
| 3. | Philadelphia Z. G. : 1.10.1879-16.6.1899 (C. E. Brown, 1925, p. 266) | 19 | 8 | 15 | |
| 4. | ♀. National Zool. Park, Washington, D.C. (A. B. Baker, 1920, pp. 143, 144, and N. Hollister, 1923, p. 93) | 20 | 0 | 10 | probable age 24 years. |
| 5. | ♂. Frankfort o. M. Z. G. : 20.4.1901 25.6.1925 | 24 | 2 | 5 | |
| 6. | ♀. Bale Z. G. : 28.9.1893-12.1.1918 | 24 | 3 | 14 | |
| 7. | ♀. Frankfort o. M. Z. G. : 25.7.1884 28.12.1914.. | 30 | 5 | 3 | |
| This was a very large animal when I saw her in Sept. 1912 and in Oct. 1913. | | | | | |

Order 15. ARTIODACTYLA.

The Artiodactyle Ungulate mammals are, with the exception of one species, clearly divided from the Perissodactyle Ungulates by their shorter lives.

All existing Perissodactyles (the Horse, Rhinoceros, and Tapir families) are large animals. Of the very small species of Artiodactyles we have little knowledge concerning their duration of life, but of most of the large species of Cattle, Sheep, Goats, Antelopes, Giraffes, Deer, Camels, and Pigs, so much evidence is available that it is safe to say that their specific longevities lie between five and twelve years, and the potential longevity is about twenty-five years, or, at the most, in the case of the very largest species, such as the Giraffe and Camel, thirty years.

The exception, referred to above, is the Hippopotamus. This colossus appears to have a specific longevity of fourteen to eighteen years, and a potential longevity of something over forty years.

Family BOVIDAE.

Subfamily BOVINÆ.

The species of large Cattle, Zebu, Gayal, Yak, Bison, and Buffalo, have a specific longevity of nine to twelve years, and a potential longevity of twenty to twenty-five years, or even, in very rare cases, of thirty years.

The Anoa, the one species in this subfamily of smaller stature, appears to be shorter lived, so far as the comparatively few records of this animal show.

The Domestic Ox, *Bos taurus*, seldom gets a chance of growing to old age; even the English white feral Park Cattle in zoological gardens appear to be slaughtered and used for meat when ten to twelve years old. The maximum, record in the London Z. G. is of a "Chartley × Vaynol" bull, born 30.5.1898 killed 15.5.1912, 13 years 11½ months. As an instance of to how long a Cow can live and give milk, the Earl of Onslow, P.C., O.B.E., V.P.Z.S., in a letter of 19.4.1930, wrote that a non-pedigree Guernsey cow, imported from Cornwall to the Scilly Islands, and thence brought to Clandon Park, Guildford, in October 1921, was destroyed, owing to old age and infirmity, 4.4.1930, when her age was supposed to be about twenty years. Lord Onslow said he could vouch personally for her being not less than 16 years 10½ months old. She bred regularly. Her last calf, a heifer without a tail, born 31.3.1929 was weaned 4.4.1929. The milk yield of the old cow from 4.4.1929 to 4.4.1930, that is, for the last 365 days of her life, was 8575 lbs.

The Zebu, or Domestic Humped Ox, *Bos indicus*, a more tractable beast than *Bos taurus*, is a favourite exhibit in zoological gardens, and so there are many records of its living to ages of between ten and fourteen years. In the Sudan, as the result of many enquiries carried on through many years, the oldest bull that I know of died when probably between eleven and twelve years old, and the oldest ox when probably nearly twelve years old. No records of old cows were obtained. In exceptional cases Zebras live much longer than fourteen years; thus a cow born in the London Z. G. 19.9.1869 survived till 6.11.1888, 19 years 1 month 17 days, and another female received in the National Zool. Park, Washington, D.C., "when about three years old," 11.4.1899, died 25.3.1921 (N. Hollister, 1922, p. 89), having lived in the Park 21 years 11 months 14 days, and being probably 25 years old.

A pair of Gayals, *Bibos frontalis*, were received in the London Z. G. 4.10.1880 in exchange from the Calcutta Z. G.: the male lived in London till 9.12.1895, and the female till 19.6.1896, 15 years 2 months 5 days and 15 years 8 months 15 days respectively.

In spite of the high altitudes from which it comes, the Yak, *Poephagus grunniens*, is a hardy animal in zoological gardens even near sea-level, and is capable of breeding up to, at least, about eighteen years of age.

Six definite instances of long-lived Yaks are:—

| | Years | months | days. |
|---|-------|--------|-------------------|
| 1. Frankfort o. M. Z. G. (M. Schmidt. 1880, p. 308) | 15 | 3 | 8 |
| 2. ♀. London Z. G. born 12.10.1894, died 13.11.1910 | 16 | 1 | 1 |
| 3. ♂. " " presented 24.8.1914, living 3.11.1930 | 16 | 2 | 9 and left alive. |
| 4. National Zool. Park, Washington, D.C. (A. B. Baker 1927 p. 94) | 18 | 3 | 0 |
| 5. ♀. Dublin Z. G. purchased 3.12.1908, living 11.12.1930 | 22 | 0 | 8 and left alive. |
| 6. ♂. Rotterdam Z. G. born 24.8.1882, died 17.12.1904 | 22 | 3 | 23 |

European Bison, *Bison bonasus*.

A pair of European Bison were presented by the Duke of Bedford, K.G., F.R.S., P.Z.S., to the London Z. G. 15.5.1912: the bull was killed by an American Bison 19.1.1922, after 9 years 8 months 4 days, the cow was sent to Woburn 20.6.1922, thus leaving alive after 10 years 1 month 5 days. The oldest European Bison that has lived at Woburn Abbey is a cow born there in 1909, His Grace the Duke was so kind as to give me the following information in a letter of 7.7.1930:—"There is no doubt as to the date of birth, and I have been personally acquainted with her ever since. She would therefore be 21 years old. She had a calf last year, and is, I think, again in calf this year. She shows age in her appearance, and has certainly lost many teeth. I should say that if she had not been fed on crushed oats she would have died before now."

Prof. Ludwig Heck has been so good as to have the archives of the Berlin Z. G. looked through concerning the longevity of Bison. In a letter of 14.11.1930 he kindly tells me that their longest record for a European Bison living in Berlin is of a female received 12.5.1891, which was sold 21.9.1907, after 16 years 4 months 9 days.

In the Posen Z. G. there are a pair of European Bison that were purchased in May 1924 from Herr Heinrich von Beyme, of Scharbow, near Hagenow in Mecklenburg Schwerin. The bull (by a male from Caucasia out of a female from Gatschina) was born 23.9.1911, the cow (from

Gasschina) was born 1.2.1913. Both are still vigorous and breeding 2.5.1930 (K. Szczerkowski, 1930), at the ages of 18 years 7 months 9 days and 17 years 3 months 1 day, respectively.

R. Lydekker (1914) states that a male European Bison, "believed to have been thirty years old," was shot by Mr. Walter Winans, in the preserve of Count Josef Potocki at Pilawin, Volhynia, Russia. How was the animal's age arrived at?

American Bison, *Bison bison*.

Records of the life of the American Bison are sufficiently numerous to be nearly conclusive: the specific longevity is 10 to 13, the potential at least 23 years. Fourteen individual records to be mentioned:—

| | Years months days. | | | |
|--|--------------------|----|----|------------------|
| 1. Philadelphia Z. G.: born 28.9.1910, living 1.7.1925 (C. E. Brown, 1925, p. 266) | 14 | 9 | 3 | and left alive. |
| 2. ♂. London Z. G.: presented 31.5.1902, killed 28.4.1917. | 14 | 10 | 28 | |
| 3. ♀. Dublin Z. G.: 8.9.1913–10.1.1929 | 15 | 4 | 2 | |
| 4. ♂. Belle Vue Z. G., Manchester: died in Sept. 1901 | 15 | 9 | 0 | |
| 5. ♀. London Z. G.: presented 31.5.1902, killed 18.6.1918. | 16 | 0 | 18 | |
| 6. ♀. Bâle Z. G.: born 7.6.1899, died 13.12.1915 | 16 | 6 | 6 | |
| 7. Jardin des Plantes, Paris: 2.5.1911–20.4.1928 | 16 | 11 | 18 | |
| 8. ♂. Dublin Z. G.: presented 8.9.1913, living 11.12.1930 | 17 | 3 | 3 | and left alive. |
| 9. ♀. Bâle Z. G.: 22.10.1896–25.3.1914 | 17 | 5 | 3 | |
| 10. ♂. Berlin Z. G.: 3.4.1902–7.11.1920 (L. Heck, in letter of 14.11.1930) | 18 | 7 | 4 | |
| 11. ♂, born in Hamburg Z. G. in 1904. Rotterdam Z. G.: 23.10.1905–16.11.1924 | 19 | 0 | 23 | age c. 20 years. |
| 12. ♂. Cologne Z. G. (Report for 1912, p. 6) | Nearly 20 | 0 | 0 | |
| 13. ♂. National Zool. Park, Washington, D.C.: born 24.5.1907, died 4.9.1927 (W. M. Mann, 1929, p. 100) | 20 | 3 | 10 | |
| 14. ♀. Rotterdam Z. G.: 18.6.1880–13.5.1903 | 22 | 10 | 25 | |

Certain published statements about American Bison living to extraordinary ages must be referred to.

H. Scherren (1908) refers to a Bison in the London Z. G. as being still alive in 1853, after about 24 years there, and W. B. Tegetmeier (1869), writing of the London Z. G., mentions "a female bison, now dead, lived in the Gardens for thirty-three years."

Both these statements appear to refer to a young cow Bison presented to the Society by the Hudson's Bay Company 24.10.1829, which, by Tegetmeier's account, would have died in 1862, but the MS. Daily Occurrence Book records no Bison as having died in 1862, or in 1859, 1860 or 1861.

C. V. A. Peel (1930, p. 208) states that in the Belle Vue Z. G., Manchester, a Bison "purchased prior to 1869, from the Marquis of Breadalbane, lived over thirty-three years in the Gardens."

Asiatic Buffaloes.

All records of longevity for *Bubalus bubalis* in Europe, Egypt, or America, as far as I know, are surpassed by one from Australia, of between 29 and 30 years. Mr. A. C. Minchin, in a letter of 22.10.1930 from Adelaide, writes:—

"According to our records the animal was purchased in Ceylon, arrived at the [Adelaide Zoological] Gardens 12.4.1886, died 1.8.1915, being blind for some time before it died."

This is the individual Buffalo mentioned by Mr. D. Seth-Smith (1909).

Four instances may be given of the life of the Anoa, *Anoa depressicornis* :—

| | Years | months | days. |
|--|-------|--------|-------|
| 1. Hamburg Z. G. (Report of 1902, p. 11) | 10 | 8 | 0 |
| 2. ♂. London Z. G. : 10.5.1871-24.11.1882 | 11 | 6 | 14 |
| 3. ♂. National Zool. Park, Washington, D.C. 12.11.1905-24.7.1918; "fully adult" when received; "had been showing extreme age" for two years before death (N. Hollister, 1920, p. 72) | 12 | 7 | 12 |
| 4. ♂. Rotterdam Z. G. (R. Lydekker, 1909) | 12 | 9 | 0 |

African Buffaloes.

The Cape, or African, Buffalo, *Syncerus caffer* (*Bubalus caffer*), often lives ten years in captivity, and may reach an age of at least sixteen. A bull caught, when a few days old, near Roseires, on the Blue Nile, towards the end of January 1909, arrived in the Giza Z. G. 17.8.1909, and was still there, alive and vigorous, 31.3.1924, when 15 years 2 months old. A cow from the same locality, caught in January 1910, was brought to Giza 12.12.1910, and was also alive and well 31.3.1924, age 14 years 2 months. A cow lived in the London Z. G., 14.10.1870-12.5.1885, 14 years 6 months 28 days, and a bull purchased 24.6.1870 was sent to Liverpool 21.12.1885, after 15 years 5 months 27 days in London; but as Mr. Cross was allowed to have the Buffalo at the small value of £20 the animal was presumably showing signs of senility.

Subfamily CAPRINAE.

Sheep.

The Domestic Sheep, *Ovis aries*, is not often given a chance of living to its full span of life, and the exact age of old animals in private ownership may be difficult to prove; but it may be said, I think definitely, that ewes of twelve years may bear healthy lambs and rams of fourteen may still be in service (cf. H. J. Elwes, 1913). M. Schmidt (1880, pp. 307, 308) recorded that in the Frankfort o. M. Z. G. an "*Ovis strepsiceros*" lived 11 years 10 months 16 days, an "African Domestic Sheep" 13 years 3 months 2 days, and that an "*Ovis campestris*" was still alive after 13 years 8 months 10 days. An "Iceland Ram" living in the Belle Vue Z. G., Manchester, 1.1.1908, had been there for 11 years 9 months.

In my personal experience of Sheep-keeping there has been only one ewe which lived to over seven years, but several rams. A "Hedjaz" Black-headed Ram born in the Giza Z. G. 8.6.1899, died 22.10.1911, apparently from old age, at 12 years 4 months 4 days. An Egyptian Four-horned Ram purchased when young, but full grown 10.8.1907, died 11.5.1922, apparently from sheer old age; he was a friendly pet, and lived in the Giza Z. G. 14 years 9 months 1 day, and must have been over 15 years and possibly nearly 16 years of age.

A hybrid Ewe (Mufion ram × Soa ewe), born in the London Z. G. 2.4.1920, is still alive there, 3.11.1930, after 10 years 7 months.

The Mufion, *Ovis musimon*, appears to have a specific longevity of seven or eight years, but, in the sheltered and well-fed life of a zoological garden,

1st. My sister, Mrs. S. T. P. Prideaux, who has specialized in goat-keeping in the south of England, has very kindly collected and placed at my disposal a mass of records. This may be summarized by saying that female domestic Goats in England frequently live to eight and to ten years and longer, in several cases to fifteen years, and one died aged seventeen. One at least thirteen, and probably sixteen, years of age, that was still alive "had lost one front tooth and had some other teeth in poor condition." Goats of ten and twelve years old will produce kids regularly, and may go on being mothers to fourteen or perhaps fifteen years. One Goat is known to have had thirty-two kids in her life. Eight- to ten-year-old Goats give a good milk yield, one twelve years old gave a "good supply," and one fifteen years old was giving 5 lbs. of milk daily. Of males, the "Winner of Stud Goat Cup for best English male, 1923" had been born in 1916, and was still alive 25.4.1926.

2nd. The records of the London Z. G. show that many Goats—wild, feral, and domestic—of both sexes have lived there for 8 and 10 years, a few females to 11 or 12 years, and four females to over 13 years. Two of these were from Crete: one, presented 30.9.1871, died 24.10.1884, 13 years 24 days: the other, presented 17.7.1909, died 9.5.1924, 14 years 9 months 22 days. The other two (*Capra aegagrus*) were both born in the Menagerie: one, born 24.4.1914, was killed 15.8.1928, 14 years 3 months 21 days; the other, born 24.4.1913, is said to be still alive, 4.11.1930, at the age of 17 years 6 months 10 days.

3rd. Observations made in Egypt and the Sudan, Oct. 1898–March 1924:—Eight to ten years appears to be the full length of life for Goats: I only obtained six definite instances of Goats living to over eleven years. One of the ordinary black, domestic Goats of the northern Sudan, a male, born in the spring of 1905, was brought to Giza, where it died 7.8.1916, aged 11 years and 3 or 4 months. A female Circassian Goat born in the Giza Z. G. died when aged 11 years 7 months 15 days. A male Circassian Goat, presented to the Giza Z. G. when he was fully adult, 18.11.1902, died 15.6.1913, over 12 years old. A female domestic Goat that belonged to Sir Murdoch Macdonald, K.C.M.G., C.B., died at Aswan in the winter of 1912–1913, aged 14 years. A male Angora Goat, which died in the Giza Z. G. 23.11.1914, was over 14 years 10 months in age, and a wild female Goat, from Crete, which died in the Giza Z. G. 26.11.1915, was over 16 years old, probably 16 years 7 months.

These last two were "soldier goats": their respective histories are of interest, and illustrate the strong viability of *Capra hircus* under varied circumstances and climates. Officers of the Welch Regiment and of the Rifle Brigade kindly helped me to compile these biographies.

The male Angora Goat was picked up in South Africa by the 1st Battalion, the Welch Regiment (41st Foot), to replace the Queen's Goat, which died early in the war (1899, 1900). The new Goat was present at five actions, and marched at the head of the Regiment into the cities of Kroonstadt, Johannesburg, and Pretoria on their occupation by British troops. It was deposited in the Giza Z. G., Egypt, 4.3.1914, where it died suddenly, 23.11.1914. Its total weight, whole, after death, was 48 kilos (106 lbs.): the animal was very fat, and no lesion sufficient to account for death was found at a post-mortem examination. So this is a case of a male Goat living to over fourteen years ten months without showing obvious signs of senile decay.

The female, *Capra hircus cretensis*, was caught, when a kid, on Mount Ida, in Crete, in 1899. She accompanied the 2nd Battalion, Rifle Brigade, to South Africa in September 1899, and went through the war, 1899–1902, qualifying for two medals and four clasps. Afterwards she was with the Battalion for two years in Cairo and one year in Khartoum, and then returned to Egypt

and was deposited in the Giza Z. G., 18.10.1905. She was mated with a Nubian Ibex \times Domestic Goat hybrid buck, and produced kids 15.5.1907 and 2.6.1908. She died 26.11.1915, aged probably 16 years 7 months or nearly 16 years 8 months. Post-mortem examination showed the animal to be very thin, there were slight adhesions of right lung, but all other organs were healthy.

The other Wild Goats, Tur, Ibex, and Markhor, agree with *Capra hircus* in an ordinary life of eight to ten years, but the taller and bulkier species appear to have a greater potential longevity.

A male Caucasian Tur, *Capra caucasica*, presented by Prince Paul Demidoff to the London Z. G. 16.1.1908, lived there till 29.9.1922, 14 years 8 months 13 days, and four female hybrids, between *Capra caucasica* and the Asiatic Ibex, *Capra sibirica*, born in the London Z. G., have had remarkably long lives. Of these four : one born 21.6.1914 died 10.8.1928, after 14 years 1 month 17 days ; one born 6.7.1912 died 22.7.1930, after 18 years 16 days ; and two are still living, 3.11.1930—one born 21.6.1914 being 16 years 4 months 12 days old ; the other, born 28.7.1911, having reached the age of 19 years 3 months 5 days.

A female Asiatic Ibex, *Capra sibirica*, presented by H.H. the Maharaja of Chamba to the London Z. G. 27.3.1908, was killed by order 16.7.1930, after living in London for 22 years 3 months 19 days. Mr. D. Seth-Smith assures me, 17.9.1930, that there is no doubt as to the identity of the individual animal.

The true Alpine Ibex, *Capra ibex*, of Europe, is a very rare animal in zoological gardens. Specimens exhibited are usually hybrids with domestic Goats ; one such hybrid lived in the London Z. G., 3.11.1862–15.6.1871, 8 years 7 months 12 days. In the Jardin des Plantes, Paris, the record for an Ibex, 18.7.1899–15.4.1909, is 9 years 8 months 27 days. In the Schönbrunn Menagerie, Vienna, a male Ibex has lived 14 years, and two females have had to be killed when 17 years old (O. Antonius, 1929, p. 103). On the eve of his eighty-third birthday, which was on 21.7.1930, Herr Mader, of St. Gall, Switzerland, in telling me of his life-long experience of Ibex, and without knowing of my special interest in the duration of life of animals, said that the stories of Alpine Ibexes living to great ages were fables ; he put twenty years as the extreme maximum length of life of an Ibex.

One hundred and seventy-four individuals of the Nubian Ibex, *Capra nubiana*, lived in the Giza Z. G. from October 1898 to March 1924. From notes on these I can say :—

1st. Males and females have an equal span of life.

2nd. The thirty individuals that lived longest averaged a life of about 8½ years.

3rd. Four males and four females lived for over ten years, but not one reached eleven years.

The Thar, *Hemitragus jemlahicus*, although a native of the Himalayas, lives long, and breeds, in zoological gardens at low levels in western Europe and in eastern North America. The length of life appears to be the same as that of the domestic Goat, 8 to 10 years ; rarely one finds individuals living to 12, 13, and 14 years, and in a very few instances to over 15 and 16 years. One born in the Jardin des Plantes, Paris, 2.8.1901, died 26.10.1916, 15 years 2 months 24 days. A female born in the London Z. G. 24.7.1888 lived till 14.1.1904, 15 years

5 months 20 days, and another female born in London 17.6.1897 died 3.6.1914, aged 16 years 11 months 16 days. H. S. Ferguson (1902, p. 17) has recorded that a Nilgiri Thar, *Hemitragus hylocrius*, lived in the Trivandrum Z. G. for 16 years 11 months.

Subfamily *RUPICAPRINAE*.

Goat-Antelopes.

Few men can know so much of the life, habits, and varieties of the Chamois, *Rupicapra rupicapra*, in Switzerland and the neighbouring parts of Austria and Italy as the veteran hunter and preserver Herr Mader, of St. Gall. Speaking 20.7.1930, he said that it could be taken as certain that no Chamois lived to twenty years, and that one fifteen years of age would be an old animal.

In the Bâle Z. G. four Chamois have lived for over ten years, the maximum being a female, born there 2.6.1901, which died 23.1.1915, 13 years 7 months 21 days. In the London Z. G. a male received in exchange, 22.4.1907, lived till 23.12.1922, 15 years 8 months 1 day, and in the Jardin des Plantes, Paris, a Chamois lived, 7.10.1890–26.8.1907, 16 years 10 months 19 days.

Two male Goral Goat-Antelopes, *Naemohedus goral*, have lived well in the London Z. G., one, 3.6.1904–3.11.1915, 11 years 5 months, and one, 16.3.1881–9.11.1898, for 17 years 7 months 23 days.

The Takin, *Budorcas taxicolor*, is another example of a mountain animal living well in the London Z. G. as far as the only two individuals ever brought alive to England show. The male lived, 22.6.1909–7.5.1918, 8 years 10 months 15 days. The female, received 25.1.1923, is still alive, 3.11.1930, after 7 years 9 months 8 days.

A male Rocky Mountain Goat, *Oreamnos americanus*, caught in British Columbia "when about a fortnight old," 12.6.1899, arrived in the London Z. G. 6.6.1900, and died there 19.1.1909, after living in captivity 9 years 7 months 7 days.

Subfamily *OTIBOVINAE*.

A female Musk-Ox, *Oribos moschatus*, lived in the London Z. G., 9.10.1919–10.12.1929, 10 years 2 months 1 day.

Subfamily *BUBALINAE*.

The large Antelopes of the genera *Bubalis* (*Alcelaphus*), *Damaliscus*, and *Connochaetes* do not appear to live much longer than Goats: fifty selected individual records give an average of about eleven years and an absolute maximum of about twenty years. The Gnus in captivity generally do better than the Hartebeests, but do not exceed them in length of life.

The Bubal Antelope, or North African Hartebeest, *Bubalis buselaphus*, is now extinct. The last survivor, a female, died in Paris in 1923. I last saw her in July 1921, and made the following notes:—

Colour—entirely pale reddish yellow, except the long hairs on the tail, which distally become blackish, and the tips of the ears, which are brownish.

Horns and hoofs—pale horn colour.

Iris—yellow,

Records of the longevity in captivity of eight individuals of this vanished species are available :—

| | Years | months | days. |
|--|-------|--------|-------------------|
| 1. London Z. G.: 30.7.1832-17.2.1840 | 7 | 6 | 17 |
| 2. Jardin des Plantes, Paris : 21.10.1894-3.12.1913 | 9 | 1 | 12 |
| 3. (sp. ?) Hanover Z. G.: died in 1903 or 1905 Over | 10 | 0 | 0 |
| 4. ♀. Jardin des Plantes, Paris : born 29.9.1913, died 9.11.1923 | 10 | 1 | 10 |
| 5. Frankfort o. M. Z. G. (M. Schmidt, 1880, p. 307) | 12 | 10 | 0 and left alive. |
| 6. ♀. London Z. G.: 4.10.1893-27.4.1897 | 13 | 6 | 23 |
| 7. Frankfort o. M. Z. G. (M. Schmidt, 1880, p. 307) | 16 | 8 | 29 |
| 8. Jardin des Plantes, Paris : 19.7.1897-14.6.1916 | 18 | 11 | 4 |

A female Blesbok, *Damaliscus albifrons*, lived in the London Z. G., 2.6.1911-24.11.1924, 13 years 5 months 22 days, and in the Antwerp Z. G., 26.9.1929, I was shown a Blesbok which Mr. L. Star told me had been there since 1912, so 17 years old and still alive.

A herd of White-tailed Gnu, *Connochaetes gnou*, has been maintained for about forty-five years by Mr. F. E. Blaauw, F.M.Z.S., in his park at Gooilust in Holland : the maximum age attained by an individual member of this herd has been stated to be between sixteen and seventeen years (H. Scherren, 1909). In June 1930 Mr. Blaauw, while showing me his Gnus, told me that he had no records longer than this.

Eight definite records of individuals in public zoological gardens are :—

| | Years | months | days. |
|---|-------|--------|--------------------|
| 1. ♀. Giza Z. G.: born 12.7.1912, living 31.3.1924 | 11 | 8 | 19 and left alive. |
| 2. ♂. Bâle Z. G.: 29.6.1910-17.7.1922 | 12 | 0 | 18 |
| 3. London Z. G.: 28.9.1830-2.11.1842 | 12 | 1 | 4 |
| 4. Philadelphia Z. G.: 2.9.1881-2.12.1894 (C. E. Brown, in letter, 21.3.1930) | 13 | 3 | 0 |
| 5. National Zool. Park, Washington, D.C.: 23.6.1914-21.11.1927 (W. M. Mann, 1929, p. 100) | 13 | 4 | 28 |
| 6. ♂. London Z. G.: 11.5.1865-13.1.1879 | 13 | 8 | 2 |
| 7. Jardin des Plantes, Paris : 31.1.1912-21.11.1926 | 14 | 9 | 21 |
| 8. New York (Bronx) Zool. Park (R. L. Ditmars, 1919, p. 61) | 15 | 0 | 0 |

The Brindled Gnu, *Connochaetes taurinus*, has lived to over twelve years in the zoological gardens of London, Bâle, and Frankfort o. M.

A pair of White-bearded Gnus, *Connochaetes taurinus albojubatus*, were received in the Philadelphia Z. G. 5.6.1908 : the male died 22.2.1921, 12 years 8 months 17 days, the female died 27.7.1928, 20 years 1 month 22 days (C. E. Brown, in letter of 21.3.1930).

Subfamily CEPHALOPHINAE.

The data concerning Duikers are too scanty to form any general idea of their longevity. That these antelopes may live to nearly, or over, nine years is proved by the four following cases of individuals of the genus *Cephalophus* :—

| | Years | months | days. |
|---|-------|--------|-------|
| 1. <i>grimmii</i> , ♂. Giza Z. G.: 16.8.1907-23.3.1916 | 8 | 7 | 7 |
| 2. " ♂. London Z. G.: 28.11.1876-13.10.1885 | 8 | 10 | 15 |
| 3. <i>sylvicultrix</i> , ♂. Rotterdam Z. G.: 26.5.1891-22.5.1900 | 8 | 11 | 26 |
| 4. <i>mazwelli</i> , ♀, London Z. G.: born 8.10.1869, died 20.11.1878 | 9 | 1 | 12 |

Subfamily *NEOTRAGINAE*.

A male Gambian Oribi, *Ourebia nigricaudata*, caught in March 1867, arrived in the London Z. G. 17.5.1867, and died 6.2.1876, at an age of at least 8 years 10 months 6 days. A male Abyssinian Oribi, *Ourebia montana*, lived in the Bâle Z. G., 4.10.1910–23.6.1924, 13 years 8 months 19 days.

Subfamily *REDUNCINAE*.

Of the Reedbucks, *Redunca spp.*, there are few records of a life of over eight years, the maximum for the London Z. G. is a male *Redunca arundinacea*, 28.4.1897–30.4.1906, 9 years and 2 days.

The Waterbucks, *Kobus spp.*, are larger animals, and thrive better in captivity. Forty individuals, selected from records of animals that have lived longest in several zoological gardens, give an average of 9 years 2 months, but it should be noted that sixteen out of these forty "left alive," so that if the remainder of their days could have been counted the average would have been higher. Ten to twelve years are not uncommon ages for Waterbucks, but records of over twelve are rare: six of these are:—

| | Years | months | days. |
|--|-------|--------|--------------------|
| 1. <i>K. lechê</i> . Jardin des Plantes, Paris: 9.10.1911–23.11.1923 . | 12 | 1 | 4 |
| 2. <i>K. defassa</i> . Giza Z. G.: maximum for a male . | 13 | 1 | 22 |
| 3. Male hybrid, <i>K. unctuosus</i> ♂ × <i>K. ellipsiprymnus</i> ♀. London Z. G.: born 24.10.1903, killed 6.5.1918 . | 14 | 6 | 12 |
| 4. <i>K. lechê</i> , ♂. Antwerp Z. G.: born in 1914, before 1.8.1914 (fide Mr. L. Star). Living 26.9.1929 . | 15 | 1 | 25 and left alive. |
| 5. <i>K. unctuosus</i> , ♀. London Z. G.: 13.11.1886–8.2.1902 . | 15 | 2 | 25 |
| 6. <i>K. defassa</i> . Giza Z. G.: maximum for a female | 16 | 8 | 0 |

Subfamily *ANTILOPINAE*.

The Indian Antelope, or Blackbuck, *Antilope cervicapra*, seldom lives longer than seven years, but a very few individuals survive to twice that age or more.

| | Years | months | days. |
|--|-------|--------|--------------------|
| 1. Hamburg Z. G. (Report, 1903, p. 10) | 7 | 5 | 0 |
| 2. Philadelphia Z. G.: 28.12.1915–11.7.1923 (C. E. Brown. 1925) | 7 | 6 | 13 |
| 3. London Z. G.: four individuals have exceeded seven years. ♂, maximum, 28.10.1914–25.7.1924 | 9 | 8 | 27 |
| 4. " " ♀, " 12.1.1883–27.5.1891 | 8 | 4 | 15 |
| 5. Dublin Z. G.: ♀, born 5.6.1896, living 31.12.1904 | 8 | 6 | 28 and left alive. |
| 6. Calcutta Z. G. (Sanyal, 1892, p. 148) Circa | 9 | 0 | 0 |
| 7. Trivandrum Z. G. (H. S. Ferguson, 1900–1901, p. 17) | 9 | 0 | 0 |
| 8. Jardin des Plantes, Paris: born 10.7.1898, died 29.10.1907. . | 9 | 3 | 19 |
| 9. Bâle Z. G.: maximum of many records Circa | 10 | 0 | 0 |
| 10. New York (Bronx) Zool. Park (R. L. Ditmars, 1919) | 14 | 0 | 0 |
| 11. Egypt: ♂, born in Giza Z. G. 20.7.1907, transferred to Nousha Z. G., Alexandria, 23.3.1908, died 4.11.1921 . . | 14 | 3 | 14 |
| 12. Antwerp Z. G.: ♂, received before 1.8.1914 (fide Mr. L. Star), living 26.9.1929 | 15 | 1 | 25 and left alive. |

Gazelles.

The true Gazelles, of the subgenus *Gazella*, live for from five to six years, and very exceptionally to eleven or twelve years (these old individuals could only exist in favourable conditions of captivity); the larger Gazelles—Grant's, Soemmerring's, and Dama, of the subgenus *Nanger*—live longer, and appear to have a potential longevity of fourteen to fifteen years.

Males and females have an equal span of life.

During twenty-five years in Egypt and the Sudan I had exceptionally favourable opportunities for studying the Dorcas Gazelle, *Gazella dorcas*, both in its wild state and in captivity, in private compounds and in public gardens from the Mediterranean seaboard at Alexandria and Port Said southwards to Port Sudan, Khartoum, and Kordofan. The average life of the forty individuals noted as living longest in captivity in Egypt was 5 years 7 months 8 days; this includes nine specimens (five males and four females) that lived in the Giza Z. G. for well over seven years: only three (one male and two females) lived to over eleven years, the maximum length of life being a female that died in the Giza Z. G. 14.3.1910, having lived there for at least 11 years 5 months 8 days. The maximum for a Dorcas Gazelle in the London Z. G. is a female, received in exchange from the Giza Z. G. 14.8.1895, which lived till 13.10.1903, 8 years 2 months.

A female Persian Gazelle, *Gazella subgutturosa*, lived in the London Z. G., 12.12.1885–14.4.1895, 9 years 4 months 2 days, and a female Muscat Gazelle, *Gazella muscatensis*, 14.7.1903–13.1.1914, 10 years 5 months 29 days.

The Korin Gazelle, *Gazella rufifrons*, is a rather sturdy species; a female lived in the London Z. G., 17.6.1895–5.6.1904, 8 years 11 months 18 days, and a male living in the Giza Z. G. 31.3.1924 had been in captivity 11 years 10 months.

The rare and beautiful Slender-horned Gazelle, *Gazella leptoceros*, is seldom seen in zoological gardens: a male lived in the Giza Z. G., 14.10.1910–8.12.1921, 11 years 1 month 24 days.

A male Rothschild's Gazelle, *Gazella albonotata*, which, when quite young, was placed in my care at Mongalla in the southern Sudan, 20.6.1914, was still living in the Giza Z. G. 31.3.1924, after 9 years 9 months 11 days.

Five female Ariel, *Gazella soemmerringi*, in the Giza Z. G. averaged a life of over nine years, the oldest, which had to be killed owing to senility, 12.4.1909, was probably 14 years old, but only 10½ years were counted for her in computing the above average. A male Ariel born in the Giza Z. G. 31.1.1912 was still alive after 13 years 8 months 8 days (F. W. Borman, in letter of 8.10.1925).

A beautiful M'horr Gazelle, *Gazella mhor*, presented by M. Girard to the Paris Museum 26.1.1906, lived in the Jardin des Plantes till 18.10.1915, 9 years 8 months 22 days.

A male Ryl Gazelle, *Gazella ruficollis*, from Dongola, presented by Major-General Sir Herbert Jackson, K.B.E., C.B., to the Giza Z. G., 12.1.1911,

lived there till 1.10.1921, 10 years 7 months 19 days. A female Ryl, born in the Giza Z. G. 21.9.1912, died, apparently of simple senile decay, 2.11.1923, aged 11 years 1 month 11 days.

A male Springbuck, *Antidorcas marsupialis* (*Gazella euchores*), lived in the London Z. G., 30.3.1893–13.3.1903, 9 years 11 months 13 days.

Subfamily ORYGINAE.

The Oryx, Addax, Roan, and Sable Antelopes are large, strong animals : sixty-eight selected individuals average a life of 9 years 10 months 7 days. Males and females appear to be about equal in length of life. The potential longevity is at least eighteen or nineteen years. Maximum records in different menageries, as far as ascertained, are given below for the different species :—

Gemsbok, *Oryx gazella*.

| | | Years | months | days. |
|-------|----------------------------------|-------|--------|-------|
| 1. ♂. | London Z. G. 3.6.1914–10.10.1924 | 10 | 4 | 7 |

Beisa, *Oryx beisa*.

| | | | | |
|-------|---|----|---|----|
| 2. ♂. | London Z. G. 28.5.1874–17.11.1886 | 12 | 5 | 19 |
| 3. ♀. | " " born 12.4.1881, died 8.1.1896 | 14 | 8 | 26 |
| 4. | Jardin des Plantes, Paris 26.10.1885–3.3.1904 | 18 | 4 | 7 |

Scimitar-horn, *Oryx algazel*.

| | | | | |
|--------|--|----|---|--------------------|
| 5. ♂. | Giza Z. G. born 21.3.1908, died 30.10.1918 | 10 | 7 | 9 |
| 6. ♀. | Bale Z. G. 22.7.1910–18.9.1921 | 11 | 1 | 26 |
| 7. ♀. | Antwerp Z. G. from before 1.8.1914, living 26.9.1929. | 15 | 1 | 25 and left alive. |
| 8. | Frankfort o. M. Z. G. (M. Schmidt, 1880, p. 307) | 16 | 8 | 14 |
| 9. | Jardin des Plantes, Paris 21.10.1915, living 18.5.1930 | 14 | 6 | 27 and left alive. |
| 10. | " " " 6.5.1913, " " | 17 | 0 | 12 and left alive. |
| 11. ♀. | London Z. G. 16.9.1909–19.3.1924 | 14 | 6 | 3 |
| 12. | " " born 8.4.1853, died 16.5.1871 | 18 | 1 | 8 |

Arabian Beatrice, *Oryx leucoryx*.

| | | | | |
|--------|-----------------------------------|---|---|----|
| 13. ♂. | Giza Z. G. 30.6.1909–23.8.1915 | 6 | 1 | 23 |
| 14. ♀. | London Z. G. 19.5.1890–18.11.1897 | 7 | 5 | 29 |

Addax, *Addax nasomaculatus*.

| | | | | |
|--------|---|----|---|----|
| 15. ♂. | Giza Z. G. born 12.5.1908, died 8.12.1922 | 14 | 6 | 26 |
| 16. | New York (Bronx) Zool. Park (E. L. Ditmars, 1919, p. 61). | 15 | 0 | 0 |
| 17. ♂. | London Z. G. 4.6.1910–22.9.1924 | 14 | 3 | 18 |
| 18. ♀. | " " 13.11.1876–26.2.1895 | 18 | 3 | 13 |

Roan Antelope, *Hippotragus equinus*.

| | | | | |
|--------|--|----|---|----|
| 19. ♂. | London Z. G. 24.11.1878–23.2.1889 | 10 | 2 | 29 |
| 20. | Pretoria Z. G., S. Africa (Report for 1913, p. 13) | 14 | 0 | 0 |

Sable Antelope, *Hippotragus niger*.

| | | | | |
|--------|--|----|----|--------------------|
| 21. ♀. | London Z. G. 26.2.1895–30.12.1908 | 13 | 10 | 4 |
| 22. ♂. | Giza Z. G. purchased 9.7.1907, arrived 16.8.1907, living 31.3.1924 | 16 | 8 | 22 and left alive. |

Subfamily TRAGELAPHINAE.

Bushbucks, Marsh-Bucks, Kudus, Eland Antelopes, Four-horned Antelopes, and Nylghaie, so far as the available statistics show, agree in being, for their respective sizes, short-lived in comparison with other Artiodactyle mammals, and also agree in that in each genus the average length of life of females is longer than that of males. Both these statements are only provisional, pending larger series for comparison.

Ninety-three individuals, representing this subfamily, selected as those known to have lived longest, give an average of 8 years 1½ months. Ignoring the small Four-horned Antelope, eighty individuals of the larger Antelopes of this group give an average of only 8 years 9 months.

The longest record for a Harnessed Antelope, *Tragelaphus scriptus*, in the London Z. G. is of one presented 19.7.1921, still living 3.11.1930, after 9 years 3 months 14 days.

The West African Marsh-Buck, *Tragelaphus gratus*, does well and breeds freely in captivity, but rarely lives to even as long as twelve years. A female Selous's Marsh-Buck, *Tragelaphus selousi*, lived in the London Z. G., 14.10.1890–26.1.1905, 14 years 3 months 12 days, and a female hybrid, *Tragelaphus gratus* ♂ × *Tragelaphus selousi* ♀, born in London 12.2.1896, died 17.7.1913, giving a life of 17 years 5 months 5 days.

The longest lived Greater Kudu, *Strepsiceros strepsiceros*, in the London Z. G. was a female, 10.5.1873–6.3.1881, 7 years 9 months 26 days, and in the Giza Z. G. a female born 25.8.1910, which died 30.11.1921, aged 11 years 3 months 5 days.

The Eland Antelope, *Taurotragus oryx*, the bulkiest of all Antelopes, lives well and breeds regularly in most big zoological gardens. The records of the twenty-five individuals known, so far, to have lived longest average 9 years 2 months, the two longest being a female born in the London Z. G. 3.3.1914, which died 18.8.1926, 12 years 5 months 15 days, and one that lived in the Frankfort o. M. Z. G. (M. Schmidt, 1880, p. 307) for 15 years 4 days.

A Four-horned Antelope, *Tetracerus quadricornis*, has lived in the London Z. G., 17.4.1905–13.11.1912, 7 years 6 months 26 days, and one is said to have lived in the Pretoria Z. G., South Africa (Report, 1904, p. 10), for ten years.

The Nylghaie, *Boselaphus tragocamelus*, is almost the commonest Antelope in zoological gardens : it does well, and the females produce twins regularly, yet the maximum ages it reaches are very moderate. Sanyal (1892, p. 145) gives for the Calcutta Z. G. about eight years. H. S. Ferguson (1900–1901, p. 17) for the Trivandrum Z. G. eleven years. M. Schmidt (1880, p. 307) for the Frankfort o. M. Z. G. 8 years 11 days and 12 years 2 months 24 days. The two longest records in the London Z. G. are of a Nylghaie, born 1.12.1837, which was sent away in exchange 28.9.1847, and so left alive when 9 years 9 months 27 days old, and of a female, 20.11.1863–16.1.1876, 12 years 1 month 26 days. In the Jardin des Plantes, Paris, the two longest Nylghaie records are, 22.11.1896–3.2.1907, 20.9.1889–28.1.1902, 10 years 2 months 11 days and 12 years 4 months 8 days respectively. The only exception I have heard of is in the Antwerp Z. G., where, on 26.9.1929, Mr. L. Star showed me a female Nylghaie said to have been living there since 1908, in that case about twenty-one years old.

Family ANTILOCAPRIDAE.

Of the Pronghorned Antelope, *Antilocapra americana*, M. P. Skinner (1922, pp. 102, 103) writes :—" It is extremely difficult to determine how long antelopes live. They reach maturity at five, and, as a rule, live from three to five years longer, although at times an individual reaches the ripe old age of twelve or fifteen years."

Family GIRAFFIDAE.

Thirty-five individual Giraffes, *Giraffa camelopardalis*, that had lived for over six years in captivity, had an average life of fourteen years. Sixteen of these were males with an average of 12 years 9 months 22 days, and nineteen were females with an average life of almost fifteen years. These numbers of individuals are insufficient to prove definitely that females live longer than males, but suggest that fact.

Fifteen, out of these thirty-five individuals, lived to fourteen, or more, years; these were six males and nine females. They should be mentioned in detail:—

| | | Years months days. | | | | |
|-----|--|--------------------|----|----|--------------------|--|
| 1. | ♀ "Connie," from Kordofan, 1903. Giza Z. G. 16.2.1904-18.1.1918 | 14 | 0 | 0 | c. 14½ years. | |
| 2. | ♂. London Z. G.: born 17.3.1867, died 20.6.1881 | 14 | 3 | 3 | | |
| 3. | ♂. " " presented 12.7.1902, died 29.12.1916. | 14 | 5 | 17 | age over 15 years. | |
| 4. | ♀. " " " " " " 25.1.1917.. | 14 | 6 | 13 | age over 15 years. | |
| 5. | ♂. Basle Z. G.: 10.6.1912-12.10.1927 | 15 | 4 | 2 | | |
| 6. | ♀. London Z. G.: 24.5.1836-15.10.1852 | 16 | 4 | 21 | age over 18 years. | |
| 7. | ♀. " " 25.7.1874-24.11.1891 | 17 | 3 | 29 | | |
| 8. | ♀. Jardin des Plantes, Paris 30.6.1827-12.12.1845 | 18 | 5 | 12 | age over 20 years. | |
| 9. | ♂. Mysore Z. G.: India: received 7.1.1905, living 12.11.1903, when said to be 24 years old (A. C. Hughes, in letter of 12.11.1903) | 18 | 10 | 5 | age over 20 years. | |
| 10. | ♂. born in Jardin Zool. d'Aclimatation, Paris, living 1896 (P. L. Selater, 1898, p. 280), age | 19 | 0 | 0 | and left alive. | |
| 11. | ♀. London Z. G.: born 25.4.1853, died 21.5.1872 | 19 | 0 | 26 | | |
| 12. | ♂. " " " 22.4.1846, " 22.1.1867 | 20 | 9 | 0 | | |
| 13. | ♀. "Maggie." London Z. G.: born, of Kordofan parents, 20.9.1907; living 4.11.1930 | 23 | 1 | 14 | and left alive. | |
| 14. | ♀. Antwerp Z. G.: imported June 1878, died 20.4.1906 | 27 | 10 | 0 | | |
| 15. | ♀. Antwerp Z. G.: imported June 1878, died 22.6.1906 | 28 | 0 | 0 | | |

Family CERVIDAE.

The medium and large sized species of Deer have specific longevitys of from eight to twelve years, and potential longevitys up to twenty-three years. Very little is known of the smaller species of Deer.

Males and females appear to have lives of about equal length. Taking two hundred representative individuals of both sexes, I find that the hundred males average 10 years 4 months 9 days and the hundred females 10 years 10 months 27 days.

The Muntjac, or Barking Deer, *Muntiacus (Cervulus) spp.*, do well and breed freely in captivity, but, as far as available records go, seldom live more than

Molucca Deer, *Rusa moluccensis*.

| | | | |
|--|-------|--------|-------|
| 10. ♀. London Z. G.: born 23.4.1876, died 6.7.1894 | Years | months | days. |
| | 18 | 2 | 13 |

Philippine Deer, *Rusa philippinus*.

| | | | | |
|--|----|---|---|---------------|
| 11. ♂. Nat. Zool. Park, Washington, D.C. presented, when it was "at least four years of age," 17.10.1904; died "of senile cachexia," 22.10.1919 (N. Hollister, 1921, pp. 79, 80) | 15 | 0 | 5 | age 19 years. |
|--|----|---|---|---------------|

The few statistics available for the Rucervine Deer suggest that the genus *Rucervus* may be a long-lived one, sixteen individuals showing an average life of 12 years 1 month 15 days, but this is too small a number of individuals to draw conclusions from.

A male Swamp-Deer, *Rucervus duvaucelii*, lived in the National Zool. Park, Washington, D.C., 14 years 3 months 9 days (N. Hollister, 1914, p. 92), and three females have had very long lives in the London Z. G., 21.5.1912–3.3.1930, 17.7.1858–14.11.1876, 9.6.1906–24.6.1929, 17 years 9 months 12 days, 18 years 3 months 27 days and 23 years 15 days respectively.

A male Schomburgk's Deer, *Rucervus schomburgki*, born in the Hamburg Z. G. 15.7.1873, was received in the London Z. G. 1.12.1873, where it lived till 12.1.1887, a total life of 13 years 1 month 11 days.

An Eld's Deer, *Rucervus eldii*, has lived in New York, Bronx Park, for thirteen years (R. L. Ditmars, 1919). In the London Z. G. a male lived, 20.10.1896–28.11.1909, 13 years 1 month 8 days, and a female, 21.4.1900–19.10.1913, 13 years 5 months 28 days.

Thirty-two individual Deer of the Sika group, that lived to over six years in captivity, gave an average of ten years. A male Japanese Deer, *Sika nippon* (*Cervus sika*), born in the Rotterdam Z. G. 6.7.1910, died 31.1.1924, after 13 years 6 months 25 days. One born in the Jardin des Plantes, Paris, 24.7.1911, died 2.1.1930, 18 years 5 months 8 days. Two females born in the London Z. G. had long lives, 2.6.1884–15.6.1899, 27.7.1870–31.12.1888, 15 years 13 days and 18 years 5 months 3 days respectively.

A female Manchurian Deer, *Sika manchuricus*, received in exchange at the London Z. G. 20.8.1872, lived to 28.10.1886, 14 years 2 months 8 days.

Red Deer and Wapiti.

The Red Deer and Wapiti, forming the genus *Cervus* in the restricted sense, are proved, by abundant evidence, to be long-lived mammals, frequently living to from ten to thirteen years, and in rare instances to nineteen and even to nearly twenty-three years. The length of life of males and females appears equal. The American and Asiatic Wapiti live longer than the Red Deer, in agreement with their larger size.

Of the Red Deer, *Cervus elaphus*, in England, J. S. Huxley (1926, p. 1023) has shown that the maximum antler growth is obtained generally in the tenth year, but may be sooner, and that the oldest maximum antler growth was, in a single case, where it was not obtained till the thirteenth year. J. S. Huxley (1926, pp. 1029, 1030) gives the number of points on antlers at different ages, and in the same interesting paper implies that the normal maximum age for

this species, under favourable circumstances, is fifteen or sixteen years. This agrees with information obtained by the present writer from independent sources at St. Gall, in Switzerland.

The longest record of a male Red Deer in the London Z. G. is of one born 1.9.1878 which died 2.9.1895, 17 years 1 day, and for a female, a Barbary hind, born 19.5.1867, which lived till 16.11.1883, 16 years 5 months 27 days. R. L. Ditmars (1911) mentions two individuals living to 16 years, and one to 18 years, in the New York Zoological Society's Park, Bronx Park, New York. In the Philadelphia Z. G. a stag lived, 30.5.1904-14.6.1923, 19 years 14 days (C. E. Brown, 1905, p. 267).

The full age of the Wapiti Deer, *Cervus canadensis*, is 15 to 16 years, as stated by W. Rowan (1923, p. 112). The average age is, of course, much less, and the potential age somewhat longer. Thirty-three selected individuals in zoological gardens give an average of 14 years 5 months 2 days. Seven examples of American Wapiti living to extreme old ages are :—

| | Years | months | days. |
|--|-------|--------|-------------------|
| 1. ♂. London Z. G. : born 15.8.1856, died 2.9.1875 | 19 | 0 | 17 |
| 2. ♀. Bâle Z. G. : born 17.10.1902, died 17.11.1921 | 19 | 1 | 0 |
| 3. ♀. London Z. G. : born 17.6.1880, died 11.9.1899 | 19 | 2 | 24 |
| 4. ♀. " " " " 29.6.1881, " 23.9.1901 | 20 | 2 | 24 |
| 5. ♀. " " " " 8.9.1867, " 30.8.1889 | 21 | 11 | 22 |
| 6. ♀. New York, Bronx Park (R. L. Ditmars, 1910) | 22 | 0 | 0 and left alive. |
| 7. Jardin des Plantes, Paris. born 21.7.1883, died 29.8.1905 | 22 | 1 | 8 |

An Altai Deer, *Cervus songaricus*, deposited in the London Z. G. 10.8.1897, had to be shot 25.5.1918, after being there 20 years 9 months 15 days. Other notable records from the London Z. G. are of a male Wallich's Deer, *Cervus wallichii*, 13.3.1912-19.8.1926, 14 years 5 months 6 days, and of a male Hangul, *Cervus hanglu*, 16.11.1911-25.2.1925, 13 years 3 months 9 days.

Twenty individual American Deer of the genus *Odocoileus* average a life of 8 years 10 months 6 days. The longest records for Mule-Deer, *Odocoileus hemionus* (*Cariacus macrotis*) in the London Z. G. are of a female, presented 6.4.1883, which lived till 23.8.1894, 11 years 4 months 17 days, and of a male, born 1.7.1885, which died 16.9.1897, after 12 years 2 months 15 days. A male Peruvian Deer, *Odocoileus peruvianus*, born in Chile in 1909, which was presented to the London Z. G. 24.4.1911, lived there till 30.1.1923, when its age was at least 13 years 1 month. R. L. Ditmars (1919) has recorded a "Florida Deer" as living for 15 years in the New York Zoological Society's Park, Bronx Park, New York.

Available records of the Elk, *Alces alces*, are poor. Of the longevity of the European Elk in its wild state, H. J. Elwes (1903) wrote that the male is fully adult at seven or eight years, that senile degeneration commences at fifteen or twenty years, or sooner, and that some individuals may live to be twenty-five years old, or even more.

Reindeer.

The Reindeer, *Rangifer tarandus*, does well and breeds freely in zoological gardens ; it appears to live in general from seven to nine years, with an extreme age of about fifteen years.

L. J. Palmer, in charge of the Reindeer Experiment Station of the United States Department of Agriculture, in a letter of 1.2.1930, kindly informed me that "the oldest animal at the Reindeer Experiment Station at College, Alaska, is a steer nine years of age," but that "generally it is the opinion of the Lapp and Eskimo reindeer men in Alaska that the average life of the reindeer is fifteen years." In this case the word "average" should be taken, in all probability, to mean "full" or "maximum." While making these enquiries I find, time after time, that the word "average" is misused in this sense not only by English farmers, but also by University men. L. J. Palmer has also been good enough to send me the following note:—"In the 14th Annual Report, Introduction, Domestic Reindeer into Alaska, 1904 (1905), p. 120 (Reprint from 20th Annual Report Bureau of Animal Industry, 1903, p. 380), by S. Jackson, the following is stated: 'So far as known the natural life of the caribou is about fourteen years, as is also the case with the reindeer.—C. C. Georgeson.'"

The maximum record for the London Z. G. is of a female Reindeer, born 4.5.1913, which died 5.4.1924, 10 years 11 months 1 day. A male born in the Båle Z. G. 5.6.1914 lived till 14.9.1926, 12 years 3 months 9 days.

For the Tufted Deer *Elaphodus*, Père David's Deer *Elaphurus*, the American Deer of the genera *Blastocerus*, *Hippocamelus*, *Mazama*, and *Pudu*, for the ordinary European Roe Deer *Capreolus*, and the Chinese Water-Deer *Hydropotes*, I have not been able to secure sufficient notes to give any idea of their natural terms of life, and this also applies to the Musk-Deer of the family Moschidae, and to the Mouse-Deer, or Chevrotains, of the family Tragulidae.

Family CAMELIDAE.

Arabian Camel, *Camelus dromedarius*.

The age, over-estimated by A. G. Leonard (1894, pp. 119, 120), has been stated more correctly by A. S. Leese (1927, p. 137), who wrote: "Camels, like horses, may live to the age of forty years or more, but, also like horses, they reach the stage at which they can no longer justify their existence as a servant to man long before this. A camel at twenty years has generally reached and passed that point."

An anonymous paragraph quoted in Bull. New York Zool. Soc. 28, p. 50, 1925, is also good:—"Thirty years is reckoned by the Arabs to be the extreme limit of age for camels, whose females may produce ten or twelve calves in a lifetime. The normal age of a camel is reckoned to be something between fifteen and twenty-five years, the span of a generation, the period, as the Arab counts, between the marriage of two generations of the same family. A camel, which comes in its youth to a man as his bride's dowry, being expected to still be 'under him' on the occasion of his son's marriage."

Major D. S. Rabagliati, O.B.E., F.R.C.V.S., writes (1924, p. 24):—"No camel should be purchased for hard work before it is about six years old. Up to four years old the young camel is not sufficiently well grown and between four and a half and five and a half years of age the mouth is a complete wreck as regards the teeth. In this period of one year it obtains twelve or sixteen new permanent teeth and loses twelve or fourteen of the temporary ones. . . . The camel is probably at its prime between seven and twelve years of age."

In Egypt Camels generally are set to work when too young, and, in consequence, are worn out at comparatively early ages.

Six years is the proper age at which to start a Camel for real hard work, such as for military purposes. Up to about sixteen years a Camel may be still useful.

Definite records of Camels over 16 years old are rare.

| | Years | months | days. | |
|--|-------|--------|-------|------------------|
| 1. Frankfort o. M. Z. G. (M. Schmidt, 1880, p. 306) | 16 | 5 | 12 | |
| 2. Central Park, New York : born 16.1.1873, alive in 1890 (W. A. Conklin, 1891, p. 24) At least | 16 | 11 | 15 | and left alive. |
| 3. Philadelphia Z. G. : 4.2.1875-20.12.1892 (C. E. Brown, 1925, p. 267) | 17 | 10 | 16 | |
| 4. ♀. Bâle Z. G. : 29.5.1890-4.5.1908 | 17 | 11 | 5 | |
| 5. ♀. Berlin Z. G. : received 2.5.1888, sold in 1906 (L. Heck, in letter of 14.11.1930) | 18 | 0 | 0 | and left alive. |
| 6. ♀. born in 1898. Rotterdam Z. G. : received 14.4.1900, died 16.2.1924 | 23 | 10 | 2 | age c. 25 years. |
| 7. Jardin des Plantes, Paris : 7.10.1890-7.7.1915 | 24 | 9 | 0 | |

Bactrian Camel, *Camelus bactrianus*.

Notable examples of longevity in this species are :—

| | Years | months | days. | |
|--|-------|--------|-------|---------------------------------------|
| 1. ♀, born in the Crimea in 1855. Presented by the Royal Engineers to the London Z. G. 18.11.1856, died 30.4.1873 | 16 | 5 | 12 | [4 months, age over 17 years |
| 2. ♂. London Z. G. : purchased 20.2.1884, sold 19.2.1904 for £5, so presumably it was decrepid with age | 19 | 11 | 29 | and left alive. |
| 3. ♂, gelding. Purchased, when full grown, from Carl Hagenbeck by the Duke of Bedford, who presented it to the Zool. Society 4.4.1911. It lived in Regent's Park till 29.7.1930, when it was trans- ferred to Whipsnade Park, where it lives, 17.11.1930 | 19 | 7 | 13 | age over 22 years. |
| 4. ♀. Frankfort o. M. Z. G. : received, when young, 20.4.1895, sold 25.1.1918. I noted of this camel, 21.9.1912, when she was about 18 years old, that her humps were quite upright, whereas in a male Bactrian camel in the Giza Z. G. the humps had fallen over before he was 14 years of age | 22 | 9 | 5 | and left alive. |
| 5. ♀, born <i>circa</i> 1906: received Rotterdam Z. G. 6.3.1912, living there 1.6.1930 | 18 | 2 | 25 | [c. 23½ years, and left alive, age |
| 6. Jardin des Plantes, Paris : born 12.4.1896, died 28.4.1920 | 24 | 0 | 16 | |
| 7. ♂. Berlin Z. G. : 10.3.1900-5.10.1924 (L. Heck, in letter of 14.11.1930) | 24 | 6 | 25 | |
| 8. ♀. Bâle Z. G. : 10.6.1886-11.11.1911 | 25 | 5 | 1 | |

Hybrid Camel

A special paragraph must be given to one of the most remarkable animals that ever lived in the menagerie of the Zoological Society of London. As is well known, hybrid Camels are the result of the cross *Camelus bactrianus* ♂ × *Camelus dromedarius* ♀. These mules are regularly bred in parts of western Asia, as they have a definite value as transport animals. The existence of the opposite cross, *Camelus dromedarius* ♂ × *Camelus bactrianus* ♀, has been denied by experts, or, if admitted, it has been stated that when such a mule is born it will be an undersized weakling, useless and short-lived.

On 24.2.1881 the Society received as a present from Col. O. H. St. John, F.Z.S., a female Bactrian Camel, formerly belonging to Ayoub Khan, which

Col. St. John had "purchased from its capturers at Kandahar" (P. Z. S. 1881, p. 409). On 25.3.1881 this Bactrian gave birth to a female foal, which lived in the London Z. G. till 23.3.1898, 16 years 11 months 28 days.

There is no proof that the sire of this foal was a *Camelus dromedarius*, but there is the definite fact that the foal had only *one hump*, a large hump covering most of its back.

Lama spp.

The Lama *Lama glama*, the Huanaco *Lama huanacus*, the Alpaca *Lama pacos*, and the Vicugna *Lama vicugna* all appear to have an ordinary life-span of about twelve years. Thirty selected individuals, including all four species, show fifteen females having an average life of 13½ years and fifteen males with a life of only 11½ years.

Definite cases of Lamas living to over 15 years :—

| | | Years months days. | | |
|-----|---|--------------------|----|--------------------|
| 1. | <i>glama</i> , ♀. Dublin Z. G.; received, adult, 11.5.1907, died 23.7.1922 | 15 | 2 | 12 |
| 2. | <i>huanacus</i> , Jardin des Plantes, Paris 6.4.1912 20.6.1927 | 15 | 2 | 14 |
| 3. | .. ♀. London Z. G., 16.8.1869-29.3.1885 | 15 | 7 | 13 |
| 4. | <i>pacos</i> , Hamburg Z. G. (Report, 1903, p. 10) | 15 | 11 | 0 |
| 5. | <i>vicugna</i> , ♂. London Z. G.; presented 20.12.1913, living 11.11.1930 | 16 | 10 | 21 and left alive. |
| 6. | <i>pacos</i> , Cologne Z. G. (Report, 1911, p. 6) | 17 | 6 | 0 |
| 7. | <i>glama</i> , Philadelphia Z. G., 4.2.1888 18.8.1906 (C. E. Brown, 1925, p. 267) | 18 | 6 | 14 |
| 8. | <i>glama</i> , ♂. London Z. G.; purchased 3.6.1892, died 8.1.1911 | 18 | 7 | 5 |
| 9. | <i>huanacus</i> , ♀. London Z. G.; presented 16.8.1884, died 10.9.1903 | 19 | 0 | 24 |
| 10. | <i>glama</i> ♀. Dublin Z. G.; born 31.7.1884, died 4.11.1904... | 20 | 3 | 4 |

Family SUIDÆ.

For the Old World Pigs of the genera *Sus*, *Potamochoerus*, *Phacochoerus*, and *Babirusa* available statistics are not sufficient for a statement of average or specific longevity, but the latter may be eight or nine years, as seventy-one selected individuals give a full-life average of 10 years 3 months 10 days, and show a potential longevity of twenty years.

So far as the few figures at my disposal go of sexed individuals, 27 males and 33 females, the females have the longer life, with an average of 10 years 11 months, the average for males being 9 years 5 months.

M. A. C. Hinton (1926, pp. 18, 19) has drawn attention to the peculiar dentition of the Wart-Hog in connection with old age. This dentition, with "persistently growing teeth," which, Hinton shows, "finish growing, develop roots, and wear out" if the Wart-Hog lives long enough, does not appear to give the Wart-Hog a longer life than that of the other Old World Pigs or of the American Peccaries (S. S. Flower, 1926, p. 20).

The European, and west Asian, Wild Swine, *Sus scrofa*, live well in European and American zoological gardens; instances of exceptional old age include two animals that lived for fifteen years in the Philadelphia Z. G. (35th Annual Report, 1907, p. 13): a male in the Bâle Z. G., 14.4.1906-6.6.1921, 15 years 1 month 22 days; one that lived in the National Zool. Park, Washington, D.C., 10.9.1911-9.12.1926, 15 years 2 months 29 days (W. M. Mann, 1927, p. 97); a female, from Turkish Arabia, in the London Z. G., 6.9.1894-16.10.1910,

16 years 1 month 10 days ; and a female presented to the London Z. G. 5.3.1880, which died 11.9.1899, after 19 years 6 months 6 days.

Two instances from the Giza Z. G. may be given of African races of *Sus scrofa* living in Egypt to great ages. A male Sennar Pig, from the Fung Province of the Sudan, received, when a young animal, 1.10.1904, died 27.2.1922, having lived in the menagerie 17 years 4 months 26 days, and being probably nearly 18 years old. A female, believed to be the last genuine Egyptian Wild Pig, died of old age, 20.12.1912 : she had been in my charge for 14 years 2 months 14 days, and was at least 16, but possibly 18 or 19 years old.

Of east Asian Swine in the London Z. G., an Andaman Boar, *Sus andamanensis*, born 15.7.1867, died 20.10.1879, 12 years 3 months 5 days, and a White-whiskered Sow, *Sus leucomystax*, presented 30.5.1865, lived till 10.7.1878, 13 years 1 month 10 days.

African Bush-Pigs seldom live over ten years in Europe, but a Red River-Hog, *Potamochoerus porcus*, born in the London Z. G. 4.6.1858, died 3.2.1873, 14 years 7 months 29 days.

The record African Wart-Hog, *Phacochoerus aethiopicus*, in the London Z. G. appears to be a female, received in exchange 28.6.1894, which died 1.12.1906, 12 years 5 months 3 days. Three female Wart-Hogs, all obtained, when quite young, in the Fung Province of the Sudan, did particularly well in the Giza Z. G. One from Singa, Blue Nile, 1.7.1909, arrived Giza 17.8.1909, died 10.1.1923, 13 years 6 months 9 days. Two from Roseires, 20.9.1907, arrived Giza 17.10.1907, died 2.4.1921 and 19.3.1924, thus living, respectively, 13 years 6 months 12 days and 16 years 6 months.

A male Babirusa, *Babirusa babyrussa*, has lived in the London Z. G., 11.11.1860-9.5.1871, 10 years 5 months 28 days, and a female, 3.7.1897-6.1.1908, 10 years 6 months 3 days. I once had a female Babirusa, very tame, and a great pet, in my charge for 9 years 6 months 20 days : she was probably 12 years 3 months old when, 20.4.1908, I had to send her away alive to Hamburg.

Family TAYASSUIDAE.

A male White-lipped Peccary, *Tayassu pecari* (*Dicotyles labiatus*), was in the London Z. G., 31.8.1878-11.1.1888, 9 years 4 months 11 days.

The Collared Peccary, *Pecari tajacu* (*Dicotyles torquatus*), appears to be hardier in captivity in Europe ; males have lived in the London Z.G., 21.3.1891-15.1.1903 and 31.5.1861-14.3.1875, 11 years 9 months 24 days and 13 years 9 months 14 days respectively. An individual born in the Jardin des Plantes, Paris, 8.5.1911, died 1.3.1927, at the age of 15 years 9 months 23 days.

Family HIPPOPOTAMIDAE.

Hippopotamus, *Hippopotamus amphibius*.

The Hippopotamus is a strange and highly specialized mammal. One of its peculiarities is that when it is removed from its native haunts in the wide spaces of tropical Africa it *flourishes* in confined quarters in European and American menageries, lives to remarkable ages, and breeds regularly.

The Hippopotamus is an example of exercise not being a necessary part either of the life of an individual animal or of the capacity of reproducing its species.

In its wild state, as far as my personal observations in the Sudan go, the Hippopotamus has to take a great deal of exercise both in swimming and walking. To find suitable food it sometimes, during the night, wanders for miles on land, and the jaws get immense exercise in crushing enough coarse vegetation to provide sufficient nourishment for such a bulky animal.

In a northern zoological garden the Hippopotamus passes its days, eating and sleeping, with a walk perhaps twenty to forty yards long in summer, and much less in winter when shut up in a warmed room, and even if its water-tank is only large enough for it to immerse itself in, turn round, and move two or three yards in each direction, it keeps quite fit. Its food is brought to it, even placed in its mouth, and this food is all of the best and most nutritious procurable.

It is not unusual for Hippopotamuses in captivity to live over twenty years. Their potential longevity appears to be over forty years. As far as available figures go, female Hippopotamuses live longer than males both in average and extreme lives.

Some instances of long-lived individuals of *Hippopotamus amphibius* :—

| | | Years | months | days. |
|--------|---|-----------|--------|--|
| 1. ♂. | "Sigapo." National Z. G., Pretoria, South Africa (R. Bignalke, 1929. p. 299) | Nearly 21 | 0 | 0 |
| 2. | Jardin des Plantes, Paris : 28.7.1896-14.10.1917 . . . | 21 | 2 | 16 |
| 3. ♂. | "Said," Giza Z. G.: received from East Africa, when over a year old, 24.4.1908; living 1.11.1930 | 22 | 6 | 7 and left alive. |
| 4. ♂. | "Broek," Antwerp Z. G.: received 12.6.1881, died 14.2.1904. "Broek" and his mate "Julie," between 1886 and 1903, are said to have had fourteen young ones, about eleven of which were reared | 22 | 8 | 2 age c. 24 years. |
| 5. ♀. | Antwerp Z.G.: imported 21.4.1905, living 12.12.1930 | 25 | 7 | 21 and left alive. |
| 6. ♀. | " " " " " | 25 | 7 | 21 " " |
| 7. ♂. | "Bachit I" or "Glückliche," from the Atbara, Sudan (for rate of growth see S. S. Flower, 1908, p. 21). Hamburg Z. G.: received -8.1881. died 6.3.1910 | 28 | 6 | 6 age c. 29 years. |
| 8. | Jardin des Plantes, Paris : 11.5.1897-14.5.1924 . . . | 27 | 0 | 3 |
| 9. ♂. | "Jakob," born in Antwerp Z. G. 11.10.1887: purchased in June 1888 for the Breslau Z. G., where he died, 7.12.1914, as the result of an accident slipping on entering his bath, he injured his spine | 27 | 1 | 26 |
| 10. ♂. | Jardin des Plantes, Paris: received 19.8.1853, died 14.1.1880 | 26 | 4 | 25 |
| 11. ♂. | Berlin Z. G.: received 20.12.1893, died in 1920 | 26 | 0 | 0 |
| 12. ♂. | "Obasch." Arrived, when said to be five or six months old, at Cairo, 14.11.1849; arrived in London Z. G. 25.5.1850, died 11.3.1878 . . . | 27 | 9 | 16 { in London, ago 28 years and 9 or 10 months. |
| 13. ♀. | "Julie," Antwerp Z. G.: 12.6.1881-20.10.1909 . | 28 | 4 | 8 age c. 30 years. |
| 14. ♀. | London Z.G.: presented 22.7.1854, died 16.12.1882 | 28 | 4 | 24 age c. 29 years. |
| 15. ♀. | Belle Vue Z. G., Manchester: received 19.7.1876, died in 1906 At least | 29 | 5 | 11 age c. 30 years. |
| 16. ♀. | "Lieschen," born in Antwerp Z. G. early in 1896; arrived in Frankfurt o. M. Z. G. 18.12.1896, living there 15.9.1930 | 34 | 0 | 0 and still alive. |
| 17. ♀. | "Guy Fawkes." London Z. G.: born 5.11.1872, died 20.3.1908 | 35 | 4 | 15 |
| 18. ♀. | Jardin des Plantes, Paris: received 4.6.1855, died 3.2.1897 | 41 | 7 | 29 |

Pygmy Hippopotamus, *Choeropsis liberiensis*.

Although this species was first brought alive to the British Isles as long ago as 1873, when an individual, presented to the Royal Zoological Society of Ireland, died shortly after reaching Dublin (P. L. Selater, 1873, p. 434), it has been only during the present century that the Pygmy Hippopotamus has become a regular inhabitant of the principal zoological gardens of Europe and North America. It does well and breeds.

The first specimen received in the London Z. G., a female, "Diana," was purchased, for £300, 6.2.1913; she gave birth to a calf 1.11.1930. This gives some idea as to the longevity of this species. "Diana" is still alive, 11.11.1930, after 17 years 9 months 5 days of life in London.

Order 16. SIRENIA.

It would be extremely interesting to know what is the longevity of the Manatee, *Trichechus* (*Manatus*), and the Dugong, *Dugong* (*Halicore*), both on account of the peculiar dentition, with a series of molar teeth gradually coming into use, of both these genera and from the practical point of view in making laws to limit the killing of individuals to prevent the extermination of the species.

The toothless Northern Sea-Cow, *Rhytina*, was exterminated by man before any facts as to its length of life were known.

Unfortunately I can find no evidence of a Dugong having lived in captivity, and the records of Manatees in aquariums and zoological gardens only prove the difficulty of keeping this animal alive under artificial conditions for even two years.

Order 17. TUBULIDENTATA.

The African Ant-Bear, or Aard Vark, *Orycteropus afer*, is another example of an animal with peculiar dentition about whose specific or potential longevity nothing appears to be known. A female has lived in the London Z. G., 30.10.1884-3.2.1891, 6 years 3 months 4 days, and a male, 18.6.1869-13.3.1879, 9 years 8 months 25 days.

Order 18. PHOLIDOTA.

Even less is known of the life of the Pangolins, *Manis* spp.; there appears to be no record of one living to even two years in captivity.

Order 19. XENARTHRA.

Family CHOLOEPIDIDAE.

Two-toed Sloths, *Choloepus* spp., do well in captivity (S. S. Flower, 1930, p. 665), but the available figures are not sufficient to make statements possible as to specific or potential longevity or to compare the viability of the sexes. Fifteen individuals in six zoological gardens give an average of 5 years 7 months 6 days. A *Choloepus didactylus*, believed to have been born about 1912, acquired by the Rotterdam Z. G. 13.8.1914, died there 14.6.1924, after 9 years 10 months 1 day, aged probably about 11½ years. A pair of Hoffman's Sloths, *Choloepus hoffmanni*, lived well in the London Z. G.; the male was received 1.5.1876, the female 25.8.1876; both died 30.4.1887, the female after 10 years 8 months 5 days, the male after eleven years.

Family BRADYPODIDAE.

No one appears to have succeeded, either in Europe or America, in keeping a Three-toed Sloth, *Bradypus tridactylus*, alive for more than a few months.

Family MYRMECOPHAGIDAE.

The three longest records in the London Z. G. for the Great Anteater, *Myrmecophaga tridactyla* (*Myrmecophaga jubata*), are all of females. One received 15.9.1923 is still living, 11.11.1930, after 7 years 1 month 26 days; one purchased 24.4.1883 died 26.3.1893, 9 years 11 months 2 days; and one presented 4.10.1867 lived till 5.2.1882, 14 years 4 months 1 day.

A female Tamandua Anteater, *Tamandua tetradactyla*, was in the London Z. G., 30.1.1880–15.1.1885, 4 years 11 months 15 days.

Family DASYPODIDAE.

The commonest species of Armadillo in zoological gardens is the Hairy Armadillo, *Euphractus villosus* (*Dasypus villosus*): it lives well, and sometimes breeds in captivity. Both males and females live to ten, or more, years.

Five instances of long life in this species are:—

| | | Years | months | days. |
|-------|---|-------|--------|-------|
| 1. ♀. | London Z. G. born 2.5.1875, died 25.10.1887. | 12 | 5 | 23 |
| 2. f. | .. presented 10.10.1892, died 30.7.1905 | 12 | 9 | 20 |
| 3. ♂. | .. 7.12.1873, .. 30.1.1887 | 13 | 1 | 23 |
| 4. | Jardin des Plantes, Paris 26.12.1899–23.6.1913 | 13 | 5 | 27 |
| 5. | Rotterdam Z. G. received, when believed to be from two to three years old, 11.5.1915; living 12.12.1930 | 15 | 7 | 1 |

age c. 18 years.
and left alive.

The Apar, or Three-banded Armadillo, *Tolypeutes tricinctus*, has lived in the Berlin Z. G. for eleven years (C. C. Sanborn, 1930, p. 67).

Order 20. MARSUPIALIA.

Several forms of Kangaroos live well and breed freely in captivity: of these sufficient is known to form fairly accurate ideas of their duration of life. Wombats are stout fellows who, when once they have "dug themselves in," will live for very many years. The Zoological Society of London has been very successful in keeping several species of Australian Opossums. Over and beyond these three exceptions it must be acknowledged that we know nothing about the life-spans of Marsupials except that individuals in captivity do not appear to live out their full lives, and that many interesting genera have never been seen alive in Europe.

Family MACROPODIDAE.

The larger Kangaroos appear to live longest, with a full life of eight to nine years and an extreme of seventeen; the Wallabies live six to seven years, with an extreme of twelve; the Rat-Kangaroos five to six years, with an extreme of nine years. In each group, so far as available figures go, females average slightly longer lives than males, but the difference is very small, hardly four per cent,

Mr. A. S. Le Souef, in a letter from Sydney of 12.5.1930, writes :—" Marsupials of the genus *Macropus* are short lived; I do not think they get over twelve years often."

Examples of long-lived individuals of various species may be given in detail:—

A Great Grey Kangaroo, *Macropus giganteus*, lived in the Hamburg Z. G. (Report, 1905, p. 10) 11 years 3 months. In the London Z. G. the longest record for a male Great Grey Kangaroo is of one, born 14.5.1889, which died 3.10.1900, 11 years 4 months 19 days, and for a female is of one, born 27.7.1871, which died 31.3.1885, 13 years 8 months 4 days.

In the Giza Z. G. the longest record for a female of this species, received when adult, 16.9.1900, died 21.1.1911, was only 10 years 4 months 5 days, but two males lived longer. On 8.2.1900, a travelling menagerie being in financial difficulties at Port Said, I purchased, among other animals, a male Black-faced Kangaroo; it was very tame. The proprietor told me that this Kangaroo had journeyed about the world for years in its small wooden cage: it died in the Giza Z. G. 26.5.1911, after 11 years 3 months 18 days. How much older it actually was is unknown. An adult male Great Grey Kangaroo, received in exchange from the Melbourne Z. G., arrived in the Giza Z. G. 16.9.1900. On 23.3.1908 it was transferred to the Nuzha Z. G., Alexandria, where it died 28.9.1914, having lived in Egypt for 14 years 12 days.

A female Wallaroo, *Macropus robustus*, was in the Giza Z. G., 3.5.1900–25.3.1913, 12 years 10 months 22 days. The Hon Walter Rothschild (now Lord Rothschild, F.R.S., V.P.Z.S.) told me, 15.8.1913, that a Wallaroo that had belonged to him lived for fifteen or sixteen years.

A male Red Kangaroo, *Macropus rufus*, in the London Z. G., purchased 10.6.1860, died 5.7.1873, 13 years 25 days, and a female, born in the London Z. G. 1.3.1880, lived till 10.1.1894, 13 years 10 months 9 days. The oldest recorded Red Kangaroo appears to be one which was in the Nat. Zool. Park, Washington, D.C., from June 1912 to 3.11.1928 (W. M. Mann, 1930, p. 4), at least 16 years 4 months 3 days.

A Bennett's Wallaby, *Macropus ruficollis bennetti*, lived in the Trivandrum Z. G. for twelve years (H. S. Ferguson, 1900–1901, p. 17). A female Dama, or Derbian, Wallaby, *Macropus eugenii*, born in the London Z. G. 13.10.1875, died there 25.8.1885, 9 years 10 months 12 days. A Brush-tailed Rock-Wallaby, *Petrogale penicillata*, was in the London Z. G., 17.9.1888–13.2.1896, 7 years 4 months 26 days.

A female Gaimard's Rat-Kangaroo, *Bettongia gaimardi*, presented to the London Z. G. 25.6.1891, died 9.4.1899, 7 years 9 months 14 days. In the Calcutta Z. G. this species has lived 9½ years (Sanyal, 1892, p. 170). A Brush-tailed Rat-Kangaroo, *Bettongia penicillata*, was in the London Z. G., 9.6.1908–25.6.1916, 8 years 16 days.

The Dark Rat-Kangaroo, *Potoroüs tridactylus* (*Hypsiprymnus apicalis*), in the Frankfort o. M. Z. G. has lived, approximately, six to seven years (M. Schmidt, 1880, p. 305).

Family PHALANGERIDÆ.

The first Pygmy Flying-Acrobats, *Acrobates pygmaeus*, in the London Z. G. were two received 18.6.1840; one of these died 12.8.1843, the other 10.6.1844,

3 years 11 months 22 days. Two female Dormouse-Phalangers, *Dromicia nana*, have done well in the London Z. G., 18.6.1873–18.10.1878 and 1.5.1899–6.1.1905, 5 years 4 months and 5 years 8 months 5 days respectively.

Thirty-four individual Flying-Opossums of the genus *Petaurus* (*Belideus*) in the London Z. G. had an average life there of 6 years 6 months 7 days. A Squirrel Flying-Opossum, *Petaurus sciureus*, lived the longest, 17.5.1895–16.4.1907, 11 years 10 months 29 days. Examples of both the Long-tailed, *Petaurus australis* (*flaviventris*), and the Short-headed, *Petaurus breviceps* (*ariel*), species lived for over ten years.

The Silver-grey, or Long-eared, Opossum, *Trichosurus vulpecula* (*Phalangista rulpina*), does not do so well in captivity, as might be expected. Maximum records from several zoological gardens are all under six years. In the London Z. G. the male that lived longest, 8.5.1920–18.9.1928, was there only 8 years 4 months 10 days, and the female presented 4.7.1868, which died 26.3.1878, 9 years 8 months 22 days, appears to be the maximum record for England.

A male Short-eared Opossum, *Trichosurus caninus*, was in the London Z. G., 15.6.1870–27.11.1877, 7 years 5 months 12 days, and an individual of this species lived in the Hamburg Z. G. (Report for 1904, p. 11) for 8 years 11 months. A Ring-tailed Opossum, *Pseudochirus peregrinus*, was in the London Z. G., 17.6.1922–19.2.1928, 5 years 8 months 2 days.

Family PHASCOLOMIIDAE.

Of Wombats, *Phascolomis* spp., fourteen selected individuals show an average life of 11 years 4 months 8 days. A Wombat, possibly Tasmanian, lived in the Frankfort o. M. Z. G. 15 years 9 months 14 days (M. Schmidt, 1880, p. 305). The three longest-lived Wombats in the London Z. G. were a *Phascolomis mitchelli*, 25.9.1872–24.5.1888, 15 years 7 months 29 days; a *Phascolomis latifrons*, 11.3.1885–28.11.1902, 17 years 8 months 17 days; and a *Phascolomis mitchelli*, 29.3.1880–20.4.1906, 26 years 21 days.

Family PERAMELIDAE.

The Rabbit-eared Bandicoot, *Paragalia lagotis*, appears to be the only species that has lived for any appreciable time in Europe. In the London Z. G. one received 7.7.1848 lived till 25.3.1852, 3 years 8 months 18 days, and of two males received 26.5.1899, one died 2.3.1904 and one 1.6.1904, 4 years 9 months 6 days and 5 years 6 days respectively. In the Frankfort o. M. Z. G. individuals have lived for 4 years 22 days, and for 7 years 2 months (M. Schmidt, 1880, p. 305).

Family DASYURIDAE.

The three following records from the London Z. G. are the longest that I have been able to obtain from all sources: they cannot represent the full life-span of the larger Dasyuride Marsupials:—Zebra Wolf, *Thylacinus cynocephalus*, ♀, 14.11.1884–2.4.1893, 8 years 4 months 18 days. Tasmanian Devil, *Sarcophilus harrisii*, ♀, 21.6.1866–27.3.1872, 5 years 9 months 6 days. Native-Cat, *Dasyurus viverrinus*, 7.5.1877–27.3.1884, 6 years 10 months 20 days.

Order 21. MONOTREMATA.

The Duck-billed Platypus, *Ornithorhynchus anatinus*, has not been brought alive to Europe, and one imported into North America had but a brief life there.

The Spiny-Anteaters, or Echidnas, have frequently been exhibited in northern zoological gardens, where they live five to ten years, and rarely for much longer. An Australian Spiny-Anteater, *Tachyglossus aculeatus* (*Echidna hystrix*), was in the Amsterdam Z. G., 10.5.1903–25.2.1918, 14 years 9 months 15 days, and one received in the Philadelphia Z. G. 3.10.1903 was still alive there 18.12.1930, after 27 years 2 months 15 days.

Dr. C. Emerson Brown, in a letter of 18.12.1930 from Philadelphia, writes that this Echidna is "in excellent condition. It remains inside its box, with a bed of dirt, during the entire day, coming out each evening just at dusk to feed. Its food during this entire time consists of one egg broken into a pan, and one pint of milk poured into another pan. The animal does not like them mixed, but goes from one pan to the other until the food is entirely eaten. Once in a while it comes out during the day, but when it does, I always have a feeling that something is wrong with it, as this is not its custom. I think this is the world's record for an animal of this type."

A New Guinea Bruijn's Spiny-Anteater, *Zaglossus bruijnii* (*Proechidna nigroaculeata*), lived in the Amsterdam Z. G., 5.9.1911–13.5.1920, 8 years 8 months 8 days; a second, also imported in 1911, was still alive in the Berlin Z. G. 13.12.1930, after 19 years 3 months. A third and fourth individual from the same importation were purchased by the Hon. Walter Rothschild (now Lord Rothschild, F.R.S., V.P.Z.S.), who deposited them in the London Z. G. 27.11.1912. One died 14.2.1919, after 6 years 2 months 17 days in Regent's Park; the other is still living, 14.12.1930, after 18 years 17 days, and is at least 19 years 4 months old.

7. CONCLUSIONS.

Two things concerning the duration of life of mammals are evident :—

1. There are a few species of which the main facts are known, as man, lion, cat, dog, horse, oxen, goat, giraffe, hippopotamus, and kangaroo.
2. Nothing is known of many of the most interesting groups.

Other conclusions are :—

1. The longest lived mammal is man, living to, and over, 100 years. The Primates, monkeys and lemurs, appear to be, for their size, the longest-lived Order of Mammals. Fruit-eating bats also, for their size, are very long lived.
2. The only mammals besides man that are known to exceed 50 years are the Asiatic elephant, and, in very rare cases, the horse.
3. Few other species reach, or exceed, 30 years: these are baboons, cats (very rarely), bears, seals (?), whales, African elephant, the horse family, rhinoceros, tapirs, and hippopotamus.
4. With these long-lived exceptions, and the short-lived exceptions that follow, the usual oldest ages to which mammals can live may be put, according to species, at about from 12 to 25 years.
5. The short-lived mammals, with a maximum of 6 to 7 years, are dormice, rats, mice, jerboas, and other small rodents.
6. The very short-lived mammals, with lives of under 5 years, as far as known, are the insectivora and the insectivorous bats.

Why is it that hedgehogs or tenrecs will not live to 4 years in captivity, while echidnas will live 20, or even 27 years ?

The following table gives some comparative idea of the known potential longevity of various groups of mammals :—

| Years | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 |
|-----------------------|---|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1. Chimpanzees & Mias | | | | | | | | | | | | | | |
| 2. Gibbons | | | | | | | | | | | | | | |
| 3. Old World Monkeys | | | | | | | | | | | | | | |
| 4. American Monkeys | | | | | | | | | | | | | | |
| 5. Lemurs | | | | | | | | | | | | | | |
| 6. Fruit-Bats | | | | | | | | | | | | | | |
| 7. Felidae | | | | | | | | | | | | | | |
| 8. Viverridae | | | | | | | | | | | | | | |
| 9. Hyænidæ | | | | | | | | | | | | | | |
| 10. Canidae | | | | | | | | | | | | | | |
| 11. Mustelidae | | | | | | | | | | | | | | |
| 12. Procyonidae | | | | | | | | | | | | | | |
| 13. Bears | | | | | | | | | | | | | | |
| 14. Sea-Lions | | | | | | | | | | | | | | |
| 15. Seals | | | | | | | | | | | | | | |
| 16. Squirrels | | | | | | | | | | | | | | |
| 17. Beavers | | | | | | | | | | | | | | |
| 18. Mice, Rats, etc. | | | | | | | | | | | | | | |
| 19. Porcupines | | | | | | | | | | | | | | |
| 20. Agoutis | | | | | | | | | | | | | | |
| 21. Hares & Rabbits | | | | | | | | | | | | | | |
| 22. Elephants | | | | | | | | | | | | | | |
| 23. Equidae | | | | | | | | | | | | | | |
| 24. Rhinoceroses | | | | | | | | | | | | | | |
| 25. Tapirs | | | | | | | | | | | | | | |
| 26. Bovidae | | | | | | | | | | | | | | |
| 27. Giraffes | | | | | | | | | | | | | | |
| 28. Deer | | | | | | | | | | | | | | |
| 29. Camels & Lamas | | | | | | | | | | | | | | |
| 30. Pigs | | | | | | | | | | | | | | |
| 31. Hippopotamuses | | | | | | | | | | | | | | |
| 32. Kangaroos | | | | | | | | | | | | | | |
| 33. Wombats | | | | | | | | | | | | | | |
| 34. Echidnas | | | | | | | | | | | | | | |

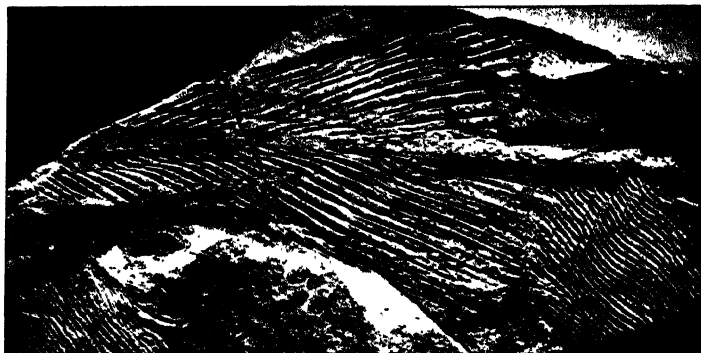
8. LITERATURE REFERRED TO.

1. ALDOUS, S. E.—*J. Mamm. Baltimore*, 11, pp. 80, 81. 1930.
2. ANDERSEN, KNUD.—“On the Determination of Age in Bats.” *J. Bombay Nat. Hist. Soc.* 25, pp. 249-259. 1917.
3. ANDERSON, J.—*Zool. Egypt, Mamm.* 1902.
4. ANTONIUS, O.—“Beobachtungen an Einhufern in Schönbrunn.” *Zool. Gart. Leipzig*, 1, pp. 19-25, 87-98, 163-182. 1928; & pp. 289-296. 1929; 2, pp. 261-274. 1930.

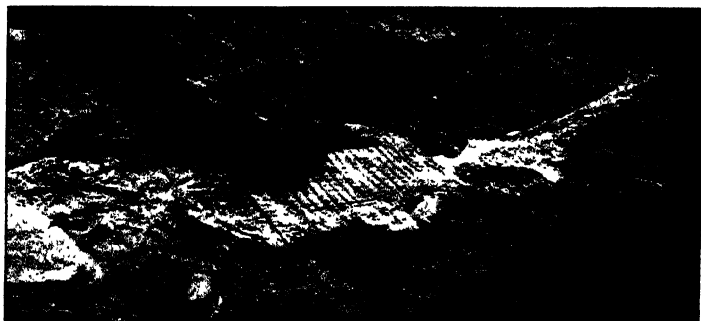
5. ANTONIUS, O.—" Ueber Steinwild." Zool. Gart. Leipzig, **2**, pp. 95-105. 1929.
6. ARMANDI, LE CHEV. P.—" Histoire militaire Éléphants." Paris, 1843.
7. ASHBROOK, F. G., & HANSON, K. B.—U.S. Dept. Agricul. Circular **107**, p. 3. Washington, D.C., 1930.
8. BAILEY, V., & SPERRY, C. C.—U.S. Dept. Agricul. Tech. Bull. **145**, p. 7. Washington, D.C., 1929.
9. BAKER, A. B.—Smithsonian Publication **2086**. 1912.
10. " " J. Mamm. Baltimore, **1**, pp. 143, 144. 1920.
11. " " Ann. Rep. Nat. Zool. Park for 1926. Washington, D.C., 1927.
12. BARRETT-HAMILTON, G. E. H.—" History of British Mammals." 1911, 1912.
13. BARTLETT, A. D.—" Wild Animals in Captivity." 1898.
14. BEAUX, O. DE. " Bemerkungen über die Haselmaus." Zool. Gart. Leipzig, **2**, pp. 286-298. 1930.
15. BENNETT, E. T.—" Gardens and Menagerie of Zool. Soc." p. 105. 1830.
16. BENSON, J. T.—" Parks & Recreation," p. 290. 1924. (Quoted by C. E. Johnson, 1927.)
17. BIGALKE, R.—" The Longevity of Wild Animals in Captivity." S. Afr. J. Nat. Hist. Pretoria, **6**, pp. 297-302. 1929.
18. BLANFORD, W. T.—" Fauna of British India. Mamm." 1891.
19. BROWN, C. EMERSON.—" Longevity of Mammals in the Philadelphia Zool. Garden." J. Mamm. Baltimore, **6**, pp. 264-267. 1925.
20. CAVALRY JOURNAL, London.—Many notes about Horses, esp. **12**, pp. 235, 236. 1922; **13**, pp. 17-20. 1923; **18**, p. 365. 1928; **20**, p. 151. 1930.
21. COCKS, A. H.—" Field," London, **108**, p. 822. 10.11.1906.
22. CONKLIN, WILLIAM A.—Report of the Director, Central Park Menagerie, New York, year ending 31.5.1873. New York, 1873.
23. " " Supplementary Report for remainder of 1873. New York, 1874.
24. " " Report for the years 1874 and 1875. New York, 1876.
25. " " " " year 1876. New York, 1877.
26. " " " " " 1877. " " 1878.
27. " " " " " 1878. " " 1879.
28. " " " " " 1879. " " 1880.
29. " " " " " 1888. " " 1889.
30. " " " " " 1889. " " 1890.
31. " " " " " 1890. " " 1891.
32. CRISP, EDWARDS.—P. Z. S. 1860, p. 177.
33. CURZON OF KEDLESTON, THE MARQUIS, K.G.—" British Government in India," **2**. London, 1926.
- DE BEAUX. See BEAUX, O. DE.
34. DITMARS, R. L.—Bull. New York Zool. Soc. **22**, pp. 60-62. 1919.
35. DUNCOMBE, CECIL.—" Field," London, **95**, p. 524. 21.4.1900.
36. ELWES, H. J.—P. Z. S. 1903, pp. 133-151.
37. " " Yearb. Amat. Menag. Cl. Maidstone, p. 113. 1913.
38. FERGUSON, H. S.—" Report on the Trivandrum Museum and Public Gardens for 1899-1900." Trivandrum, Travancore, India.
39. " " Ditto, for 1900-1901.
40. " " " " 1901-1902.
41. FLOWER, S. S.—Egypt, Public Works Dept., Z. G., Special Report, no. 2. 1907. Cairo (National Printing Dept.), 1908.
42. " " Egypt, Public Works Dept., Z. G., Special Report, no. 4. Mammals, pp. 11-22. Cairo, 1909.
43. " " Ditto, no. 5. Mammals, pp. 11-127. Cairo, 1910.
44. " " " Zoologist," London, 1911, pp. 281-295, 335-345, 416-427.
45. " " Rep. India, 1913, Egypt. Govt. Zool. Serv. Public. **26**. Cairo, 1914.
46. " " Rep. 1914-1918, " " " " " **39**. " 1920.

47. FLOWER, S. S.—Proc. Linn. Soc. London, Session 136, p. 20. 1926.
48. " " P. Z. S. 1929, pp. 659-669. 1930.
49. FLOWER, W. H. Cat. Osteol. Mus. R. Coll. Surg. London, 2. 1884.
50. GEBBING, J.—'50 Jahre Leipziger Zoo.' Leipzig, 1928.
51. GOODWIN, G. G. "The First Living Elephant in America." J. Mamm. Baltimore, 6, pp. 256-263. 1925.
52. GRAY, Capt. ROBERT W.—"Growth and Longevity of Whales." 'Nature,' London, 123, pp. 910, 911. 1929.
53. GRIFFITH, R. C.—P. Z. S. 1848, p. 52.
- HAMILTON, G. E. H. B. See BARRETT-HAMILTON
- HANSON, K. B. See ASHBROOK & HANSON.
54. HATT, R. H.—"The Red Squirrel." Roosevelt Wild Life Ann. Syracuse. U.S.A. 2, p. 76. 1929.
55. HINTON, M. A. C.—Proc. Linn. Soc. London, Session 138, pp. 18. 19. 1926.
56. HODGSON, B. H.—P. Z. S. 1834, p. 98.
57. HOLLISTER, NED.—Ann. Rep. Nat. Zool. Park for 1917. Washington, D.C., 1919.
58. " " " " " 1918. " " 1919.
59. " " " " " 1919. " " 1920.
60. " " " " " 1920. " " 1921.
61. " " " " " 1921. " " 1922.
62. " " " " " 1922. " " 1924.
63. " " " " " 1923. " " 1925.
64. " " " " " 1924. " " 1925.
65. HOWELL, A. BRAZIER, & LITTLE, LUTHER. "Additional Notes on California Bats." J. Mamm. Baltimore, 5, p. 261. 1924.
66. HUXLEY, J. S. P. Z. S. 1926, pp. 1021-1035.
67. INDIAN FIELD, Calcutta. —Notes about Horses, number of 6.7.1905.
68. JOHNSON, C. E. Roosevelt Wild Life Bull. Syracuse, U.S.A. 4, p. 606. 1927.
69. KERBERT, C. P. Z. S. 1904, 1, p. 430, footnote.
70. KLUGH, A. BROOKER.—J. Mamm. Baltimore, 8, pp. 6-8. 1927.
71. KUIPER, K.—"Ueber periodischen Farbenwechsel bei *Sciurus finlaysonii*." Z. Säugetierk Berlin, 2, pp. 174-176. 1929.
72. KUMMERLOWE, H.—Zool. Gart. Leipzig, 2, p. 106 *et seq.* 1929.
73. LEESE, A. S. 'A Treatise on the One-humped Camel in Health and in Disease.' (Haynes & Son), Stamford, Lincolnshire. No date [actually 1927].
74. LEONARD, A. G.—'The Camel.' (Longmans, Green & Co.), London, 1894.
- LITTLE, LUTHER. See HOWELL & LUTHER.
75. LYDEKKER, E.—'Country Life,' London, 25, p. 729. 22.5.1909.
76. " " 'Field,' London, 123, p. 836. 18.4.1914.
77. MACKENZIE-ASHTON, G.—'Country Life,' London, 20, p. 852. 8.12.1906.
78. MANN, W. M.—Ann. Rep. Nat. Zool. Park for 1925. Washington, D.C., 1925.
79. " " " " " 1927. " " 1927.
80. " " " " " 1928. " " 1929.
81. MITCHELL, Sir PETER CHALMERS.—"On Longevity and Relative Viability in Mammals and Birds; with a Note on the Theory of Longevity." P. Z. S. 1911, pp. 425-548.
82. MONTAGU, I. G. S.—P. Z. S. 1922, pp. 932, 933.
83. NAUNDORFF, ELISABETH.—"Der Siebenschläfer als Hausgenosse." Z. Säugetierk. Berlin, 4, pp. 54-56. 1929.
84. OUSTALET, E. 'La Nature,' Paris, 1900, pp. 378, 379.
85. PALLARY, P.—Bull. Soc. Hist. Nat. Afr. Nord., Alger., 19, p. 100. 1928.
86. PARVULESCU, V.—"La famille de Chevaux sauvages du jardin des Plantes de Paris." Bull. Mus. Hist. nat. Paris (2), 1, pp. 298-303. 1929.
87. PEEL, C. V. A.—"Zoological Gardens of Europe." 1903.
88. POCOCK, R. I.—P. Z. S. 1905, 2, pp. 169-180.
89. " " " " 1906, p. 567.

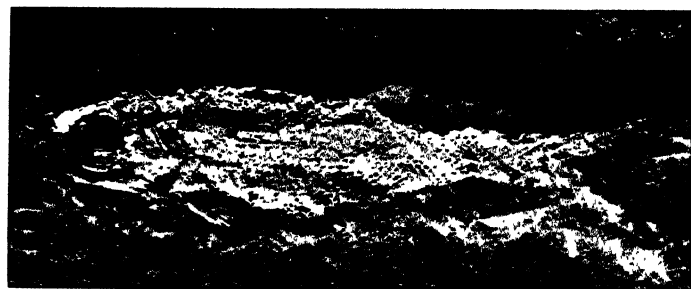
90. POCOCK, R. I. —P. Z. S. 1911, p. 990.
91. " " 'Field,' London, **122**, p. 722. 4.10.1913.
92. " " " " **123**, p. 354. 14.2.1914.
93. " " " " **124**, p. 844. 14.11.1914.
94. " " " " **130**, p. 871. 15.12.1917.
95. " " P. Z. S. 1918, p. 303.
96. RABAGLIATI, D. S.—"The Dentition of the Camel." Ministry Agriculture, Egypt. Cairo (Govt. Press), 1929.
97. RENSHAW, GRAHAM.—'Final Natural History Essays.' (Sherratt & Hughes), London & Manchester, 1907.
98. RIDLEY, H. N.—"An Account of the Menagerie at the Botanic Gardens at Singapore, from its Foundation in 1859 to its end in 1905." J. Straits Branch R. Asiatic Soc. No. **46**, pp. 133-194. 1906.
99. ROBINSON, Sir SYDNEY M. J. Bombay Nat. Hist. Soc. **30**, pp. 456-458. 1925.
100. ROLLESTON, Sir HUMPHRY DAVY.—"Concerning Old Age." 'Nature,' London, **120**, Supplement to No. 3009, pp. 2-12. 2.7.1927.
101. ROSS, R. C.—J. Mamm. Baltimore, **11**, pp. 76, 77. 1930.
102. ROWAN, W. J. Mamm. Baltimore, **4**, p. 112. 1923.
103. SANBORN, C. C. J. Mamm. Baltimore, **11**, pp. 61-68. 1930.
104. SÁNYÁL, R. B.—'Handbook of the Management of Animals in Captivity in Lower Bengal.' Bengal Secretariat Press, Calcutta. March 1892.
105. SCHEEREN, H.—P. Z. S. 1907, **1**, p. 434.
106. " " 'Field,' London, **112**, p. 513. 12.9.1908.
107. " " " " **113**, p. 376. 27.2.1909.
108. " " " " **117**, p. 281. 11.2.1911.
109. SCHEWIER, Z. Anat. Entw. Gesch. Berlin, **88**, pp. 469-499. 1928.
110. SCHMIDT, MAX. "On the Duration of Life of the Animals in the Zoological Gardens at Frankfurt-on-the-Maine." P. Z. S. 1880, pp. 299-319.
111. SCHNEIDER, KARL MAX.—"Einiges zur Leipziger Löwenzucht," in Gebbing, "50 Jahre Leipziger Zoo," pp. 114-141. Leipzig, 1928.
112. SCHWARZ, E.—Zool. Gart., Leipzig, **2**, p. 90. 1929.
113. SCLATER, P. L.—P. Z. S. 1873, p. 484.
114. " " P. Z. S. 1898, p. 280.
115. SETH-SMITH, D. —Avicult. Mag., London, **7**, p. 136. 1909.
116. SITWELL, W. H. HUET.—'Field,' London, **108**, p. 736. 27.10.1906.
117. SKINNER, M. P.—J. Mamm. Baltimore, **3**, pp. 102, 103. 1922.
SMITH, D. S. See SETH-SMITH, D.
SMYTH, Maj.-Gen. N. M., V.C., K.C.B. See CAVALRY JOURNAL.
SPERRY, C. C. See BAILEY & SPERRY.
118. SUMNER, F. B.—J. Mamm. Baltimore, **2**, pp. 79-81. 1922.
119. SZCZERBOWSKI, K.—"Die Posener Wisente." Zool. Gart. Leipzig, **3**, pp. 153, 154. 1930.
120. TEGETMEIER, W. B.—'Field,' London, **33**, p. 468. 5.6.1869.
121. TOWNSEND, C. H.—Bull. New York Zool. Soc. **29**, p. 218. 1926.
122. " " "The Public Aquarium." Rep. U.S. Comm. Fish. for 1928, Appendix 7. Bureau of Fisheries Document **1045**. Washington, D.C., 1929.
123. VOSSELER, J.—Zool. Gart., Leipzig, **2**, pp. 1-9. 1929.
124. WADE, OTIS.—"The Behaviour of certain Spermiophiles, with special reference to Aestivation and Hibernation." J. Mamm. Baltimore, **11**, pp. 160-188. 1930.
125. WALTON, M. A.—'A Hermit's Wild Friends,' p. 97. Boston, 1903 (quoted by R. H. Hatt, p. 76. 1929).
126. WARD, A. E.—J. Bombay Nat. Hist. Soc. **30**, pp. 253-259. 1925.
127. YERKES, R. M., & YERKES, A. W. 'The Great Apes,' pp. 543, 544. Yale University Press, 1929.



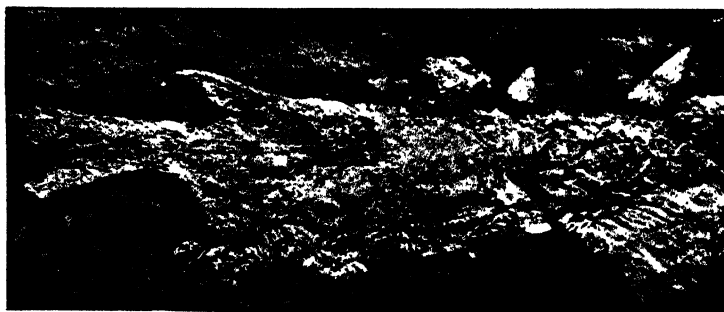
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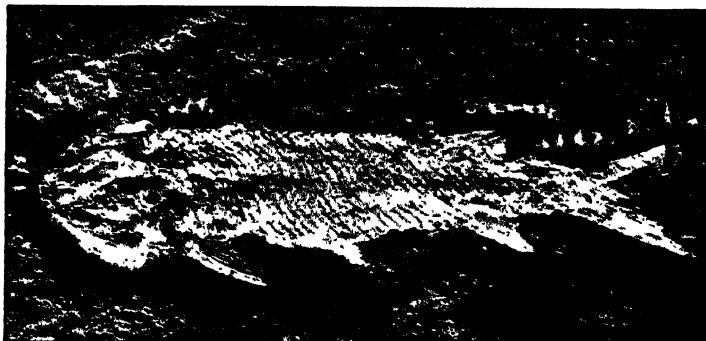
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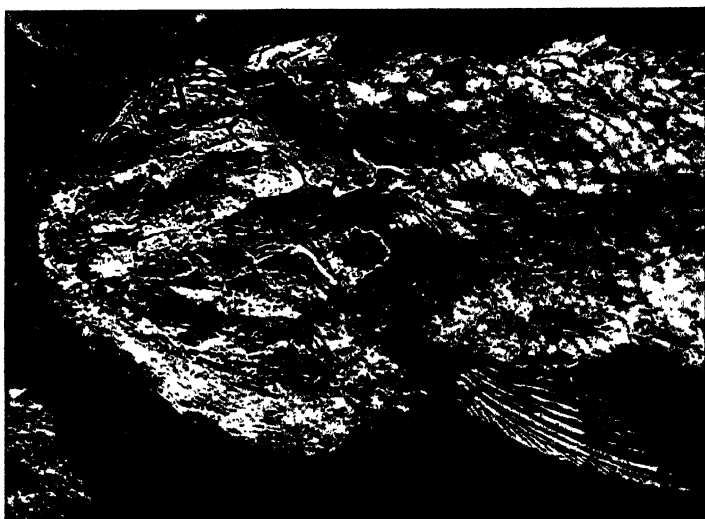
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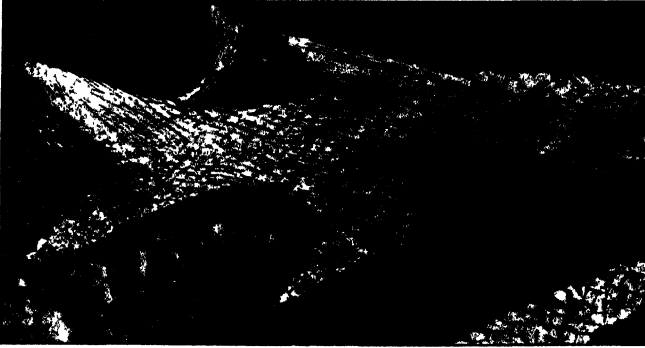
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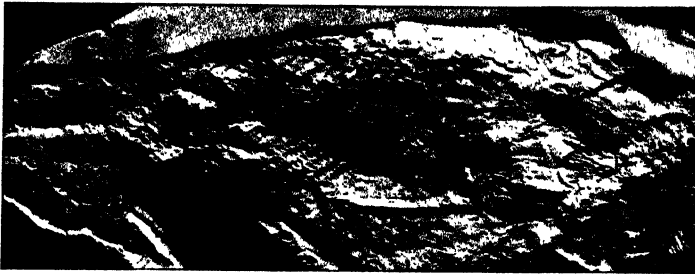
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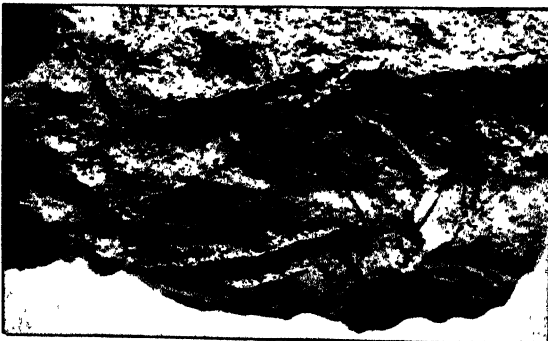
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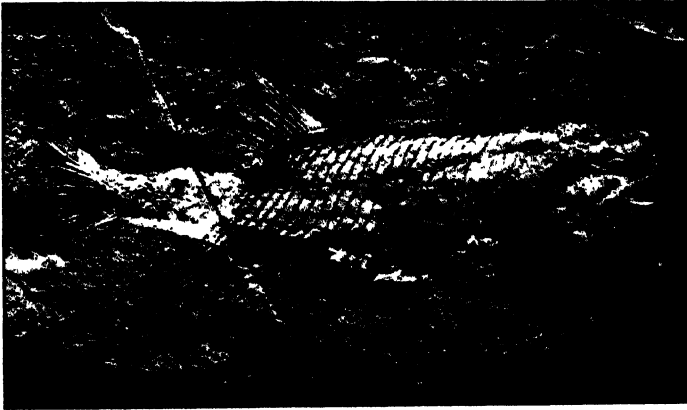
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13. On Fossil Fishes from the Karroo System, and some General Considerations on the Bony Fishes of the Triassic Period. By JAMES BROUGH * (the Victoria University, Manchester).

[Received September 25, 1930: Read November 18, 1930.]

(Plates I.-IV.†; Text-figures 1-19.)

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1. NOTE ON THE OCCURRENCE OF FOSSIL FISH AT BEKKER'S KRAAL, DIST. ROUXVILLE, ORANGE FREE STATE. By Prof. D. M. S. WATSON, F.R.S.

The fauna of fossil fish which form the subject of this paper occurs in a layer, about 2 cm. in thickness, which lies somewhat below the middle of a bed of sandstone whose total thickness is about 40 cm. This bed itself is a member of a series whose total thickness is of the order of 10 metres. The exposure from which I collected lies on the north bank of a small river at a point lying about 600 yards south of the homestead of the farm Bekker's Kraal, Dist. Rouxville, Orange Free State, where the river turns from a generally east-west to a south-north direction. It is within 100 yards of the road to Smithfield, which crosses the farm.

The sandstones are grey in colour, but weather brown, the surface becoming deeply iron stained. They are well bedded, broken faces showing a fine stratification; but they are silicified, so that they have become very tough, and when unweathered are difficult to break along the bedding-planes.

The fish are abundant within a very thin belt, the bulk of the sandstone showing no trace of them.

I was taken to this locality by Mr. A. W. Higgins, of Aliwal North, who had accompanied the late Mr. A. Brown on the occasion when he collected the series of fish described by Dr. R. Broom (1905 and 1909) as coming from a locality near the Caledon River.

The similar collection made by Dr. Kannemeyer, and described by Broom (1909), is known to have come from the same place, and so did the smaller series in the National Museum, Bloemfontein, and in the University of Stellenbosch.

The age of this series of sandstones is clear. It is known that the town of Aliwal North lies on rocks of the higher part of the *Cynognathus*-zone, which pass on to the north to Rouxville.

* Communicated by Prof. D. M. S. WATSON, F.R.S., F.Z.S.

† For explanation of the Plates, see p. 296.

The town of Bethulie lies on the *Lystrosaurus*-zone, and Prof. v. Huene found a locality, some miles east of that town, at which *Procolophon* occurred. I had earlier found *Procolophon* at Klip Kuil, north-west of Burghersdorp. The evidence of these two finds established the general trend of the base of the *Cynognathus*-zone in this region. There can be no doubt that the Bekker's Kraal fish-horizon lies low in the *Cynognathus*-zone.

Confirmation of this view is given by the series of bones described by Lydekker (Proc. Zool. Soc. 1889), now registered as R. 533 in the Geology Department of the Natural History Museum, which are recorded as coming from Bakkar's Kraal, Rouxville dist., an obvious misreading of Bekker's Kraal. They include a scapula and humerus of *Kannemeyeria* and vertebræ of *Erythrosuchus*, both characteristic *Cynognathus*-zone reptiles.

I hold that the *Cynognathus*-zone is of Lower Triassic age, on the evidence of its stratigraphical position between the Upper Permian *Cisticephalus*-zone and the Upper Triassic Red Beds and Cave Sandstones, and because of the occurrence in it of the characteristically Lower Triassic *Capitosaurus* and *Trematosaurus*.

2. LIST OF SPECIES OBTAINED FROM BEKKER'S KRAAL.

Fam. HYBODONTIDÆ.

Acrodus africanus Broom.

Fam. CÆLACANTHIDÆ.

Cœlacanthus africanus Broom.

Fam. PALÆONISCIDÆ.

"*Oxygnathus*" *browni* Broom.

Dicelopygæ macrodentatus, sp. n.

Dicelopygæ lissocephalus, sp. n.

Fam. CATOPTERIDÆ.

Dædalichthys higginsi, sp. n.

Helichthys elegans, sp. n.

Helichthys stegopygæ, sp. n.

Helichthys obesus, sp. n.

Helichthys stenipteryx, sp. n.

Helichthys grandipennis, sp. n.

Fam. PERLEIDIDÆ.

Meidichthys browni Broom.

Cleithrolepis extoni Smith-Woodward.

Cleithrolepis minor Broom.

Hydropessum kannemeyeri Broom.

3. INTRODUCTION.

The Karroo System of South Africa has been famous among palæontologists for almost a century, and in that period has yielded a rich harvest of fossil vertebrates. Reptiles are predominant, and they, along with the Amphibians, have been extensively studied. Mammals, although very rare, have also been eagerly sought for and worked over, but up to the present the fishes of the Karroo System have been somewhat neglected.

Smith Woodward described isolated specimens at various times, and Schellwein added a few sporadic observations. Broom made a serious attempt to enlarge our knowledge of this group, and, in 1905, 1909, 1912, and 1914 published papers on the Fossil Fishes of the Karroo formation, in which several genera and species were described for the first time. Nothing further was attempted until the summer of 1929, when Prof. D. M. S. Watson, who was then collecting in the Karroo beds, made a very successful visit to Bekker's Kraal, a notable locality, and was able to bring away a large and representative collection of fossil fishes. It is this collection which forms the subject of the present paper.

Most of the specimens are exquisitely preserved, and it has been possible to make out almost the complete structure in many forms. The fishes are contained in intensely hard yellow and grey sandstones, which possess a silicious cement. This latter is a very fortunate circumstance, for it allows the use of acid on the material, and it has frequently been possible to treat a head which was apparently a badly squashed mass, dissolve off the bone, and get a perfect impression of the other side as a sandstone cast. This method of preparation has been very helpful in the study of the skulls, and has allowed at least the partial reconstruction of the head in many species.

This and a little chipping were the only methods of preparation used on the South African specimens. It was necessary, for purposes of comparison, to study the Coptopterid fishes of the Newark beds of North America. In this material both fossil and matrix are susceptible to acid, and the finely tuberculated nature of the external skull-bones holds the matrix and makes chipping both arduous and unprofitable. For this material the use of a wire brush was resorted to, and it was found, a little surprisingly, that under this treatment the matrix was removed while the ganoine-covered bones remained absolutely intact. In this way it was possible to see a good deal of the structure of the skull in these fishes.

My best thanks are due to the authorities of the American Museum of Natural History, New York (through Prof. W. K. Gregory), and of the United States National Museum, Washington (through Dr. O. P. Hay), and of the University Museum of Zoology, Cambridge (Mr. Forster Cooper), for the loan of fossil fishes from the Newark beds of North America; to Prof. G. Hickling, of Armstrong College, Newcastle-upon-Tyne, for much kindly help from time to time; and to the Council of Armstrong College (University of Durham), Newcastle-upon-Tyne, for the award of the Earl Grey Memorial Fellowship, which enabled me to carry out this research. It is difficult to express adequately my indebtedness to Prof. D. M. S. Watson, of University College, London, firstly, for his generosity in allowing me to work on this extensive and highly interesting collection of fossil fishes; and, secondly, for the close interest he has shown in this work in all its stages, and for the help and advice which he has freely and frequently given.

4. SYSTEMATIC ACCOUNT OF THE FAUNA.

Fam. HYBODONTIDÆ.

Genus ACRODUS Agassiz.

ACRODUS AFRICANUS Broom.

Hybodus africanus Broom, 1909.

The collection contains a number of more or less complete specimens of this small Shark, and from these the form of the body can be reconstructed. The

mouth is very small, and is overhung by a much elongated rostrum. It bears several rows of very minute, but typically acrodont teeth. The body is elongated, and the two dorsal fins are widely separated. The anal fin is a triangular membrane which occupies the most posterior position possible, and lies immediately before the ventral lobe of the tail. The male is provided with well-developed claspers and two pairs of cephalic spines.

It is proposed to deal only with the bony fishes in this paper, and to reserve the full account of the structure and affinities of this and allied forms for a forthcoming paper on Elasmobranchs.

Fam. CŒLACANTHIDÆ.

CŒLACANTHUS AFRICANUS Broom (1905).

P. 1c and P. 2 are specimens of this little-known Coelacanth, but they are both very imperfect, and represent only the posterior part of the body. A study of these adds little to our knowledge of the species, but the accompanying photograph (Pl. I. fig. 1) gives some idea of the form and proportions of the tail.

Fam. PALÆONISCIDÆ.

"OXYGNATHUS" BROWNI Broom (1909).

The fish described by Broom under this name shows certain differences from any other species of *Oxygnathus* which are of such magnitude that it is probable that this is not a species of *Oxygnathus*, but the type of a new genus. The material in Prof. Watson's collection consists of one specimen, in counterpart, of the posterior part of the body, with the complete anal and the proximal part of the caudal fin. It is much less perfect than the type-specimen, and little can be added from it to Broom's original description.

The placing of this species in the genus *Oxygnathus* by the latter author was only provisional, and he himself remarks on the differences displayed by the South African fish in the possession of large ridge-scales on the upper caudal lobe and in the thinness of the body-scales. The difference in squamation is important, for not only are the scales much thinner, but they are differently shaped. The ornament is also dissimilar, the ridges being fewer but more regular than in *Oxygnathus*, where there is a principal oblique ridge and several subsidiary lateral ones.

The head is not figured, but from the description given it is seen that the preoperculum is of a quite different shape, and implies a less oblique suspensorium to that of *Oxygnathus*. The differences in the cheek-region are accentuated by the presence of the bone X in Broom's species.

Genus DICELLOPYGÆ, nov.

Body fusiform; head short and deep. Gape moderately wide, suspensorium only slightly oblique; orbit large and anteriorly placed. Frontals large and prominent, widest at their posterior margins; parietals small and square; preoperculum in two shanks, but with the anterior one short and broad; one X-bone present in front of the preoperculum. Four roughly quadrangular-shaped bones behind the orbit, lying together in two pairs, one immediately behind the other. Teeth conical and sharply pointed, very variable in size; there may be two unequal series, coronoid and dentary, on the lower jaw. Fins made up of numerous very fine, completely articulated rays; paired fins rather small; dorsal and anal fins triangular in shape and

variable in size ; origin of the dorsal in front of the anal, and behind the pelvics. Fulcrum present, but usually minute. Caudal fin large, equilobate, and deeply forked. Scales rhombic and ganoid ; generally smooth, but those more anteriorly placed may show faint oblique striations ; posterior margins finely pectinated.

It is necessary to erect a new genus for the reception of the two Palæoniscid species described in the following pages, for it is found that they cannot be reasonably placed with any previously-described form. With their short heads, almost straight suspensoria, and deeply-forked equilobate tails, there are few genera to which their structure nearly approximates. They do, however, possess a resemblance to certain Mesozoic Palæoniscids, particularly, as might be expected to those of the Triassic and Liassic periods.

Apart from *Coccolepis*, which is quite distinctive, there is only one well-known Liassic Palæoniscid genus, *Oxygnathus*, and this form differs very markedly from *Dicelopygæ* in the structure of the head. The Muschelkalk genus *Gyrolepis* differs from *Dicelopygæ* in several respects, the most important of which is the much greater obliquity of the suspensorium in the European form. *Urolepis*, Bellotti's genus from the Alpine Trias, is quite comparable to *Dicelopygæ* in the shape of the body and the nature of the fins, but the structure of the head is wholly unknown in this form, and, while it may resemble that of *Dicelopygæ*, there is little to indicate that it does so.

The abundant Palæoniscid material from the Triassic of Spitzbergen is in a different state of preservation from that of the Karroo fishes, and is difficult to compare with them. Where comparison is possible differences are revealed : the scales in all Stensiö's genera bear a distinct surface-ornament, while in *Dicelopygæ* they are usually perfectly smooth, but may bear two or three very faint oblique striations.

The numerous Palæoniscids from South Africa (*Atherstonia*) and New South Wales (*Myriolepis*, *Elonichthys*, *Palæoniscus*, *Apateolepis*, *Elipsopholis*, and *Coccolepis*) described by Smith Woodward, and placed into various genera, all show well-marked differences from *Dicelopygæ*. They invariably differ in the nature of the squamation, and frequently in the obliquity of the suspensorium and in the size and position of the fins.

DICELOPYGÆ MACRODENTATUS, sp. n.

There is one specimen of this species, in counterpart (P. 8 and P. 23). It represents a very elegantly-shaped fish, rather deeply fusiform in the trunk : but tapering away to a long, narrow, and delicate tail-pedicle which carries a large, deeply-forked, equilobate tail. The unpaired fins are large, but the paired fins are only of moderate proportions. The origin of the dorsal is just a little in advance of the anal. The pelvic is about midway between the anal and pectoral. The head is rather small and blunt, with a large and anteriorly-situated orbit. The gape is wide, but the suspensorium is only slightly oblique.

Dimensions :—

| | |
|----------------------|---------|
| Total length | 109 mm. |
| Greatest depth | 24 „ |
| Length of head | 23 „ |

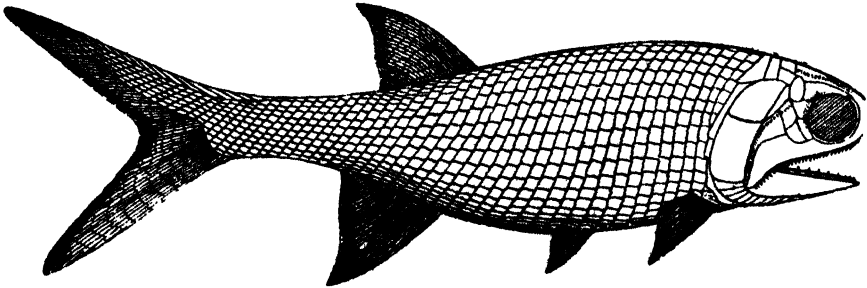
Head.

The external bones of the head display a varying degree of ornamentation, consisting of a delicate sculpturing of ridges and tubercles which is never

deeply incised. It is most prominent on the mandible, where it is in the form of a fine series of parallel longitudinal ridges. The operculum and suboperculum are quite smooth, while the preoperculum and maxilla are smooth in the centre and faintly ornamented toward the border.

The frontals are large and peculiarly shaped. They are in contact laterally with the large postfrontal over most of their length; posteriorly they adjoin the parietals, and in the postero-lateral corners they touch the supratemporal and intertemporal. Their relations to the bones of the snout are not revealed. The parietals are small and square, and have straight sutures with the supratemporals laterally and the tabulars posteriorly. The tabulars are long and narrow, and extend from the middle line to the top of the operculum. The supratemporal is small and almost regularly quadrangular; its sutures with the parietal and tabular are quite straight, and those with the opercular bones and the intertemporal are very gently curved. The intertemporal is a curiously-shaped bone: it is ovate and much higher than wide, a condition which is very unusual, for both supratemporal and intertemporal are commonly wider than high. It adjoins the postfrontal anteriorly, and is bounded by the supratemporal and the opercular bone X posteriorly. The more attenuated upper

Text-figure 1.



Restoration of *Dicelopyge macrodentatus*, gen. et sp. n. Natural size.
Drawn from the type-specimen (P. 8).

portion projects a little into the frontal, and the slightly broader base meets a concave margin of one of the postorbital bones.

The postfrontal is a long element, broad behind, but tapering in front almost to a point. The upper convex margin articulates with the frontal, while the lower concave one is free and forms the dorsal part of the orbital margin. The whole of the posterior border is gently excavated to meet the rounded anterior margin of the intertemporal. There are four postorbital bones which are not dissimilar in size and shape, and which tend to be roughly quadrangular. The orbit is enclosed anteriorly and ventrally by a number of narrow and delicate circumorbital ossicles. The more posterior ventral circumorbital bone shows a peculiar relationship to the postorbital bone, with which it is in contact, overlapping it and tapering away to a point dorsally.

The operculum is higher than wide and roughly quadrangular in shape, but with the dorso-posterior angle rounded. It is united along the whole of its anterior margin to the opercular bone X, which is a long, narrow element wedged between the operculum and preoperculum, and tapering to a point ventrally. The suboperculum, which is much longer than the operculum, is a high and narrow quadrangular element. It is followed ventrally by the first of a series of branchiostegal rays. The preoperculum is of characteristic

shape and is in two shanks, one narrow and vertical, the other broad and horizontal. The upper shank is shorter than in most Palæoniscids, a condition due, presumably, to the straightening of the suspensorium and the large development of postorbital bones. The lower margin of the preoperculum forms a deep concavity, almost a right angle, which is filled by the posterior end of the maxilla. The latter is a massive element, expanded behind, where it is in contact with the preoperculum, but shallowing in front below the orbit. The maxilla bears two excavations on the anterior part of its upper border, one made by the postorbital bones and the other by the orbit. The posterior end of this bone is downwardly expanded, so that it overlaps the mandible to a considerable extent. The mandible is a stout element, deep behind and tapering, gently at first, and then more abruptly to the anterior end. The upper, dentigerous border is perfectly straight. The peculiar ornamentation of this bone has been commented on above.

The maxilla is armed with a large series of sharply-pointed teeth of moderate size. On the posterior overlapping part of this bone the teeth are strongly curved, but are still at right angles to the edge of the bone, and so are projecting forwards and not downwards. There are two entirely different types of teeth in the lower jaw. The dentary bears about ten very large, sharply-pointed, conical teeth, and mesial to these there is a very numerous series of very tiny pointed teeth borne on the free upper edges of the coronoids.

The sensory canals of the head run in the bones and open to the exterior by rather large irregularly-placed pores. The system is only partially revealed, but there is indication that it is of normal Palæoniscid type. The hyomandibular canal is well displayed as it runs down the posterior border of the preoperculum. The course of the infraorbital canal can be traced in some of the postorbital bones, and that of the supraorbital canal is seen running the full length of the frontal.

Appendicular Skeleton.

The post-temporal is a long and triangular-shaped bone which adjoins the tabular in front and touches the top of the operculum below. It articulates with a very large and thickly quadrangular supracleithrum, an element which is very broad and extensively ornamented over the whole surface. The cleithrum and clavicle show a similar, but perhaps coarser, sculpturing of longitudinal ridges. The vertical extremity of the cleithrum is narrow and tapering, but the bone becomes considerably wider below, near the articulation of the pectoral fin. It narrows again anteriorly, where it is overlapped by the clavicles, and thus possesses a distinctly triangular shape.

The lepidotrichia of the fins are very fine, and are all completely jointed; they also exhibit a fine thread-like branching at their distal extremities.

The pectoral is a rather small fin with a wide unstricted base, and consists of eighteen rays. The anterior edge of the fin is covered by numerous small fulcra.

The pelvic is similarly small and wide-based. It has thirteen rays and an anterior fringe of tiny fulcra.

The dorsal fin is large and triangular; it consists of thirty rays, and has small fulcra on the anterior border which show a concentration toward the tip.

The anal is slightly imperfect, but it is probably very similar to the dorsal in most respects. It has a minimum of forty rays.

The caudal fin is a graceful member displaying extreme heterocercy. It was almost certainly equilobate and deeply forked, although the ventral lobe is not quite complete in the type-specimen. The scaly lobe narrows very

gradually, and extends right to the end of the dorsal lobe. It is made up of small lozenge-shaped scales, and the reduction in the width of the lobe toward the tip of the tail is not accomplished by a reduction in the number of scales, but by a reduction in their size. It is seen at the tip of the tail, where the lobe is scarcely more than a millimetre wide, that it has five scales in its width. The scales are very minute and are hardly distinguishable. The lepidotrichia are very fine and very numerous; there are approximately eighty, all completely jointed and distally branched. There is a series of large fulcral scales on the upper edge of the dorsal lobe.

Squamation.

The body is covered by a number of rather small, rhombic, ganoid scales. Over the greater part of the body they are about as deep as broad, and at their maximum measure 1.5×1.5 mm. They decrease in depth to some extent dorsally, and to a considerable extent on the ventral surface, where they become exceedingly shallow. The scales are generally quite smooth, but some of those on the dorsal surface show very faint striations. The posterior borders of all the large scales are finely pectinated. There are twenty scales in a vertical row between the dorsal and anal fins, and about forty-two vertical rows on the body.

DICELLOPYGÆ LISSOCEPHALUS, sp. n.

On the large slab P. 13 there is a complete specimen of a small Palæoniscid fish (P. 13 E) of normally fusiform shape. The fins are very small, the pelvics and anal being particularly inconspicuous. The dorsal is almost completely in advance of the anal, and is mostly opposite the space between the anal and the pelvics. The pelvics are midway between the anal and the pectorals. The orbit is very large, and occupies most of the side of the head anteriorly. The gape is wide, but the suspensorium is only slightly oblique.

Dimensions :—

| | |
|----------------------|--------|
| Total length | 76 mm. |
| Greatest depth | 16 " |
| Length of head | 18 " |

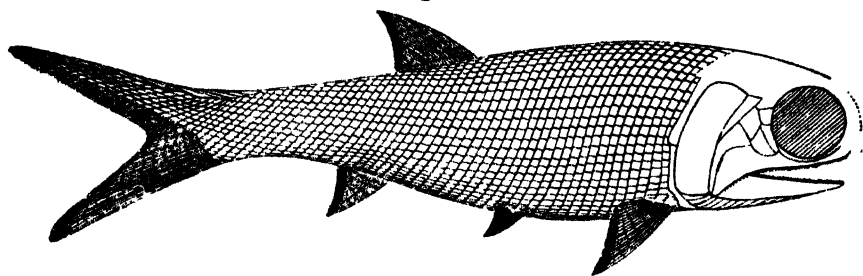
Head.

The head is fairly complete, but is squashed in such a way that the sutures cannot readily be distinguished, and it has only been possible to reconstruct the region of the jaws and checks. The bones of the head are thin and almost perfectly smooth, although there may be a suggestion of irregularity on the surfaces of some of them. The mandible, in striking contrast to all the other elements, is highly ornamented by a series of well-defined parallel and longitudinal ridges, precisely as in *D. macrodentatus*.

The suture between the operculum and suboperculum is not visible, and these bones together form a high, but narrow, quadrangular plate. Below the suboperculum there is a series of branchiostegal rays. There is a long and narrow bone X in front of the operculum, which has its greatest width dorsally and narrows to a point ventrally. The preoperculum lies in front of X and the suboperculum, and meets the posterior and part of the dorsal border of the maxilla in front. It is in two shanks, the anterior one horizontal and expanded, and the posterior one long and narrow. It is limited anteriorly by the postorbital bones, of which there are four, all very much in the same

condition as in the previous species. The maxilla is very long and expanded behind, but is excavated anteriorly by the postorbitals and by the orbit. The latter is so great that the maxilla below it becomes exceedingly slender. There is a downward expansion of the maxilla which overlaps the posterior

Text-figure 2.



Restoration of *Dicelopyge lissocephalus*, sp. n. $\times 1\frac{1}{2}$.

Drawn from the type-specimen (P. 13 e).

part of the mandible. The mandible is a regularly-shaped element; it is deep behind, but tapers gradually to a point in front. The peculiar ornamentation of this bone has been commented on above. Mandible and maxilla both bear a large number of sharply-pointed conical teeth of moderate size.

Appendicular Skeleton.

The membrane-bones of the shoulder-girdle are thin and smooth. They are not well displayed in this specimen, and little is to be seen of them except an indistinct cleithrum and a large rectangular supracleithrum. The pectoral fin is of moderate size and has a wide and unconstricted base. It is made up of eighteen rays, all completely jointed and distally branched. Fine fulcra are present along the anterior border.

The pelvic is a tiny fin in which the rays are exceptionally fine. There are about sixteen rays, all completely articulated.

The dorsal fin is triangular in shape and moderate to small in size, and consists of twenty-eight completely jointed rays which display a fine, thread-like, branching distally.

The anal is not quite complete, but it is evidently a very small fin. In all the fins the lepidotrichia are small and very closely packed. It is likely that tiny fulcra are present on the pelvic, dorsal, and anal fins as well as on the pectorals, but they are difficult to distinguish.

The caudal fin is completely heterocercal, deeply forked, and equilobate, and has seventy to eighty completely jointed, distally branched rays. A series of large fulcra is present on the dorsal lobe of the tail extending right to the tip.

Squamation.

The body has a covering of numerous, small, ganoid scales. The largest, those on the anterior flanks, are a little deeper than wide, and measure 1.2×1 mm. They decrease in depth dorsally and ventrally, but the decrease in depth of the scales on the ventral surface is not so marked as in *D. macrodentatus*, a condition, maybe, due to the smaller size of the scales in this species. Most of the scales are quite smooth, but the surfaces of the more

anterior dorsal scales and the anterior flank-scales display a series of very faint oblique striations. The posterior borders of all the scales are finely pectinated. There are about sixteen scales in a vertical row between the dorsal and anal fins, and forty vertical rows on the body, counting forward from the first lepidotrich on the ventral lobe of the tail.

Observations.

The differences between this and the previously-described species are both numerous and obvious. The body in this form is differently shaped and the tail-pedicle is much thicker; the fins are very much smaller; the dorsal fin is more anteriorly placed, and the teeth on the mandible are small and uniform and not divided into two series as in *D. macrodentatus*.

Indeed, the differences are so conspicuous that it is, perhaps, necessary to indicate certain resemblances to justify the placing of these two species together in the same genus. Palæoniscid genera have frequently been raised on fin characters, and, under such a system, the difference in the size and position of the fins, along with the differences in the shape of the body and in the nature of the dentition, might be regarded as sufficient to merit generic distinction. Against this it is to be remembered that the general build and size of the fishes is similar; that the pattern of the skull-bones, so far as is known, is identical; that the width of the gape and degree of obliquity of the suspensorium are similar; that the mandible in both is of the same shape, and has the same peculiar ornamentation; and, except for the slightly smaller size of the scales in *D. lissocephalus*, that the squamation in the two forms is sufficiently alike to belong to the same species.

Instead of regarding these forms as representatives of two distinct genera, it is preferred to look upon them as extreme forms of the same genus; and it is not unlikely that, as exploration proceeds, the South African Triassic will yield further species of this genus, probably intermediate in character between the two described here.

FAM. CATOPTERIDÆ.

Small-sized fishes, elegantly to deeply fusiform. One dorsal fin present; pelvic fins abdominal. Orbit moderate in size and anteriorly situated. Gape usually wide; suspensorium oblique in most forms, but straight in one genus (*Dictopyge*).

External bones of the skull ornamented. Frontals frequently large and elongated; parietals small, triangular or irregular in shape, and in some forms failing to meet in the middle line. A pair of dermo-supraoccipitals frequently present. Supratemporal conspicuous and fairly deep; intertemporal absent as a separate element. Postfrontal large and of characteristic shape; adjoins the supratemporal with a fairly long, straight, vertical suture. Nasals lying between the rostralo-postrostral and the prefrontals, and not entering into the border of the orbit. Maxilla large; commonly deep and plate-like behind, and always firmly attached to a large preoperculum. Mandibles stout, deep behind and tapering uniformly to the anterior end. Teeth small, sharp, and conical. Operculum smaller than the suboperculum; interoperculum not developed; branchiostegal rays certainly absent in some genera, and probably absent in all. Sensory canals of the head adhering rigidly to the Palæoniscid plan.

Membrane-bones of the shoulder-girdle large and strongly sculptured; clavicles conspicuous; postcleithral scales may be present. Dermal fin-rays

variable in condition in the paired fins, but always more or less fused ; numerous and completely articulated in the unpaired fins, where they outnumber the endoskeletal elements. Tail hemiheterocercal ; scaly lobe variable in length, and may almost extend to the tip of the tail. Scales thick, rhombic, and ganoid ; surfaces usually smooth, but may be striated ; posterior margins frequently denticulated. Scales made up of a lamellated bony layer below and a thick ganoinic layer above ; there is no intermediate cosmine layer.

Genus *DÆDALICTHYS*, nov.

Body fusiform ; head large. Gape wide ; suspensorium oblique. External surfaces of the skull-bones ridged and tuberculated ; posterior margins frequently denticulated. Skull of Palæoniscid appearance, with a long and posteriorly deep maxilla and a large preoperculum. Teeth conical and sharply pointed. Fins provided with large fulcra. Rays of the unpaired fins delicate, very numerous, and completely articulated. Rays of the paired fins stout, continuous elements. Tail abbreviate-heterocercal, with the scaly lobe extending more than two-thirds of the distance towards the tip. Body covered by rhombic, ganoid scales, the majority of which are ridged and have their posterior borders denticulated. Dorsal and ventral ridge-scales present ; those in front of the dorsal fin, and to a less extent those in front of the anal, much enlarged.

This genus is easily distinguished from the other Catopterids by the greater length of the scaly lobe of the tail, by the extensive ornamentation of the scales, and by the peculiar ornamentation of the external bones of the head.

DÆDALICTHYS HIGGINSI, sp. n.

There is only one specimen of this species, P. 6 A, which is fairly complete. The anterior end is somewhat indistinct, and the individual elements of the skull-roof and snout cannot be distinguished*. The rest of the fish is well preserved. The body is elegantly fusiform, the head large, and the fins very prominent. The dorsal fin is situated almost exactly opposite the anal, but the latter has a more expanded base. The pelvics lie about midway between the anal and the pectorals. All the fins are conspicuously fulcrated.

Dimensions :—

| | |
|----------------------|---------|
| Total length | 112 mm. |
| Greatest depth | 22 " |
| Length of head..... | 23 " |

Head.

The head is much obscured in this specimen, and only the cheek-region and jaws are distinct. The bones display an ornamentation of ridges and tubercles ; the latter have an uncommon appearance, being wider in front and tapering to a point posteriorly. The gape is wide and the suspensorium oblique. The opercular apparatus consists of an operculum and suboperculum behind and a large preoperculum in front. The maxilla is deep behind ; its posterior margin joins the preoperculum in the form of a gentle curve. A series of narrow circumorbital bones can be distinguished in front of the preoperculum and maxilla. The posterior borders of these plates are denticulated. The mandible is stout and rather deep posteriorly, and, like the maxilla, bears numerous conical teeth.

* A number of very well-preserved specimens of this species have been discovered recently, and from these it will be possible completely to reconstruct the head.

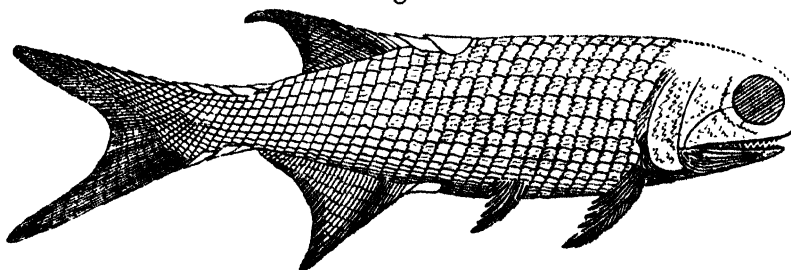
Appendicular Skeleton.

The cleithrum is a very stout bone, and is deeply sculptured into a series of longitudinal ridges and furrows. It is partly overlapped by a large supra-cleithrum which is sculptured and possesses a denticulated posterior border. The clavicles, like the other bones of the girdle, are large and ornamented.

The pectoral fin is very constricted at the base; the skeleton of the fin consists of not less than six strong, unbranched, and apparently unjointed rays. There is an anterior fringe of very large fulcral scales.

The pelvic is a smaller fin with a more expanded base. There are about twelve stout rays with large fulcra on the anterior border.

Text-figure 3.



Restoration of *Dædalichthys higginsii*, gen. et sp. n. Natural size.
 Drawn from the type-specimen (P. 6 A).

The dorsal fin is large and gracefully shaped; it is roughly triangular, but the upper angle is distally produced. There are twenty-two closely set, completely jointed rays. The ridge-scales at the base of the fin, anteriorly, are very much enlarged. Fulcra are prominent toward the tip.

The anal is a large triangular fin with an extensive base. It consists of thirty-five completely jointed rays, preceded by one enlarged scale.

The tail is deeply forked, equilobate, and abbreviate-heterocercal. The scaly lobe extends more than two-thirds of the distance to the tip. There are seventy-five very fine, closely-set, completely jointed rays. Fulcra are well developed on the dorsal lobe.

Squamation.

The scales are rhombic and ganoid. The dorsal and anterior flank-scales are deeper than wide, measuring 2×1.5 mm. They become much more shallow on the ventral surface, where they are very much wider than deep. The larger scales have a denticulated posterior margin and two surface-ridges running in a slightly oblique direction. Ridge-scales are present, and are much enlarged on the tail-pedicle and in front of the dorsal and anal fins.

Genus HELICTHYS Broom.

Body fusiform, usually of small size. Gape wide; mandibular suspensorium oblique. Skull-bones usually ornamented with ridges and tubercles of ganoiné, but may be nearly smooth. Cranial roof formed of large, usually long frontals, small triangular parietals, a pair of large dermo-supraoccipitals, and a single pair of tabulars. Supratemporal large and prominent; intertemporal not present as a separate element. Operculum small; always smaller than

the suboperculum ; opercular series completed by a small plate, the modified first branchiostegal, which lies below the suboperculum ; branchiostegal rays otherwise absent. One or two small bones (X) wedged in between the operculum and preoperculum ; one or two small bones present between the preoperculum and the orbital ring. Preoperculum in two well-differentiated shanks. Maxilla deep and plate-like behind ; shallow in front below the orbit. Mandible stout, deep behind, and tapering gradually to the anterior end. Teeth on the maxilla and mandible numerous, conical, and sharply pointed. Elements of the shoulder-girdle large and highly ornamented. Fins of moderate size : dorsal fin opposite to, or just in advance of, the anal ; pelvics midway between the anal and pectorals. Unpaired fins in a simple condition, with many fine completely jointed rays, which outnumber the endoskeletal supports ; paired fins more variable. Tail hemiheterocercal, with the scaly lobe extending one-half to two-thirds of the distance to the tip. Fulcra present on all fins except, occasionally, the pectorals. Scales rhombic and ganoid ; surfaces smooth and margins usually entire.

In his original description of this genus, Broom placed it in the Palæoniscidæ, and assigned to it three species, *H. browni*, *H. draperi*, and *H. tenuis*. The type-specimen of the first species, although without a tail, is undoubtedly a Catopterid, and the genus must therefore be a Catopterid genus. The other two species are true Palæoniscids, and must be removed from the genus *Helichthys*. *H. draperi* can be disregarded, since it is not *Helichthys*, and probably does not correspond to Smith Woodward's *Dictyopyge* ? *draperi*. The specimen figured by Broom under this name appears to represent a new species of *Dicellopyge*. The so-called *H. tenuis* quite clearly belongs to *Dicellopyge*, and may even be specifically identical with *D. macrodentatus* ; but as the type is briefly described and unfigured, it is, perhaps, better at present to regard my species as new.

Helichthys provides the largest number of species, and, with the exception of *Cleithrolepis*, the largest number of individuals in the Bekker's Kraal fauna. There are five species represented in Prof. Watson's collection, and since none of them satisfactorily corresponds to the description of *H. browni*, they must all be regarded as new.

They are a peculiar group, presenting great uniformity in respect of certain characters and great variation in others. The unusual structure of the skull is closely adhered to in all ; the squamation shows little or no variation, and the unpaired fins differ only in the number of rays. On the other hand, the pectoral fins show a striking variation ; in some they are of a type not unknown in the Palæoniscidæ, composed of many fine rays, mostly jointed, but with a short fused portion proximally. This type is without fulcra. In others there are very few stiff unjointed rays, with a conspicuous anterior fringe of very large fulcra.

This difference in the structure of the pectoral fins might be regarded as being of generic importance, but since all the fishes of this group are about the same size and shape, have the same general appearance, show little variation from a definite and unusual skull-structure, and lack branchiostegal rays, it is quite clear that we are dealing with a somewhat unusual but essentially homogeneous group of fishes, and it is doubtful if we are justified, or if any good purpose would be served, by breaking it up into more than one genus. The following five species are, therefore, all described as members of the genus *Helichthys*.

Helichthys is easily distinguished from the other three Catopterid genera. *Dædalichthys* has an almost completely heterocercal tail, highly ornamented scales, and skull-bones with denticulated margins. *Catopterus* has a tiny pair

of parietals separated by a pair of dermo-supraoccipitals and an almost homocercal tail. *Dictyopygeis* is also distinguished by the lack of a large pair of dermo-supraoccipitals and by the extreme shortness of the scaly lobe of the tail.

HELIOTHYS ELEGANS, sp. n.

This is the most slender and graceful-looking species of *Helicthys*, and is represented by three nearly complete specimens (P. 13 A & B, P. 19 A).

The body is elegantly fusiform, and the fins are only moderate in size. The dorsal and anal fins are set well back on the body; they are opposite one another at their posterior borders, but the dorsal, which is the larger fin, extends further forward, and has its anterior margin in advance of that of the anal. The pelvic is small, and lies about midway between the pectoral and the anal. The gape is wide and the suspensorium oblique, but not extensively so. The orbit is of moderate size, and occupies an extreme anterior position in the head. The head was probably broad and flat, an assumption borne out by the fact that in all three specimens it is squashed dorso-ventrally, and not laterally as in the other species of the genus.

Dimensions (P. 13 A):—

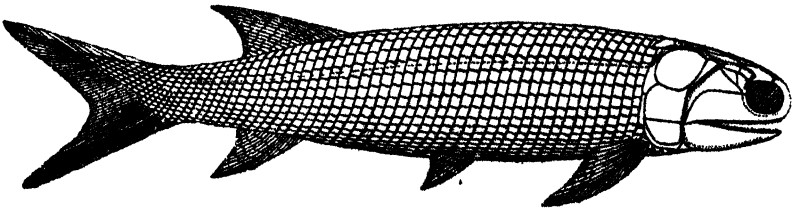
| | |
|--------------------------|---------|
| Total length | 100 mm. |
| Greatest depth | 18 " |
| Length of the head | 20 " |

Head.

The bones of the cranial roof are fairly thick, and display a faint ornamentation of ridges which, in certain elements, become indistinguishable, leaving the surface quite smooth.

The frontals are the most prominent elements in the skull-roof, and are a pair of long narrow bones with a perfectly straight suture between them. The outer margin consists of a series of very gentle concavities, into which fit the convex inner borders of certain other bones. The parietals are very small and

Text-figure 4.

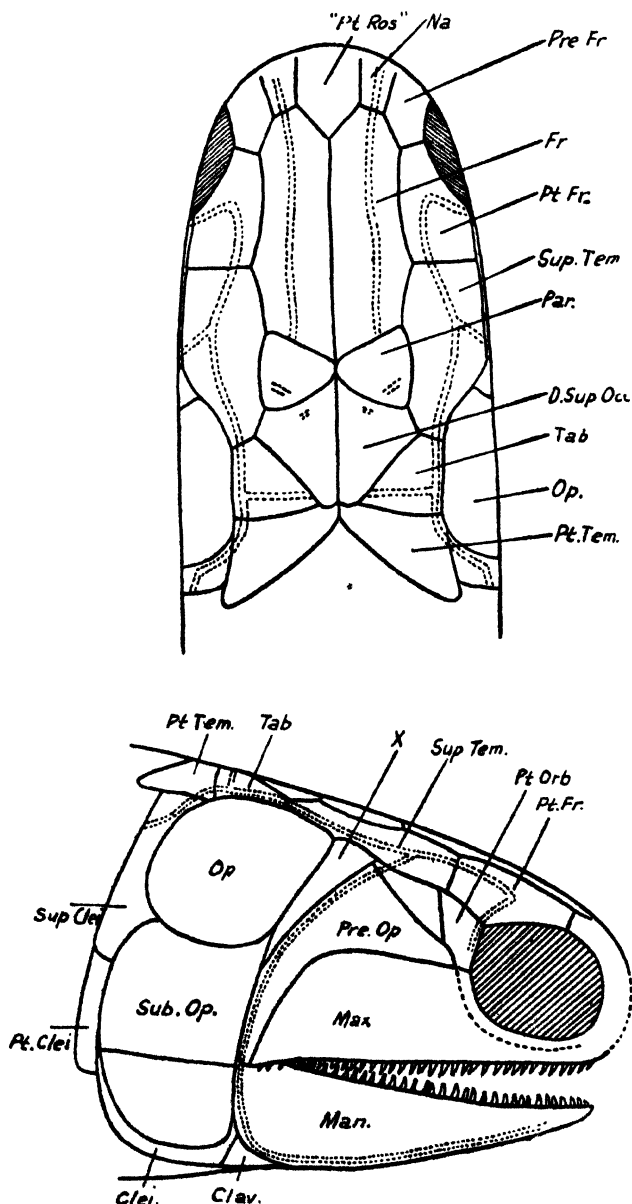


Restoration of *Helicthys elegans*, sp. n. Natural size.

Drawn from the specimens P. 13 A and P. 13 B.

triangular-shaped. The apices meet in the middle line, and the bases, which are slightly convex, abut against the supratemporals. Posterior to the parietals is a pair of very large dermo-supraoccipitals which have a long, straight, common suture in the middle line. Their oblique posterior borders overlap a pair of tabulars which, as exposed, display a triangular outline. Their true shape is probably more nearly quadrangular, for they are considerably overlapped by the dermo-supraoccipitals.

Text-figure 5.

*Helicthys elegans*, sp. n. Restoration of the head. $\times 4$.

Clav. = Clavicle. Clei. = Cleithrum. D. Sup. Occ. = Dermo-supraoccipital. Fr. = Frontal. Man. = Mandible. Max. = Maxilla. Na. = Nasal. Op. = Operculum. Par. = Parietal. Pt. Clei. = Postcleithrum. Pt. Fr. = Postfrontal. Pt. Orb. = Postorbital. "Pt. Ros." = Postrostral. Pt. Tem. = Post-temporal. Pre. Fr. = Prefrontal. Pre. Op. = Preoperculum. Sub. Op. = Suboperculum. Sup. Clei. = Supracleithrum. Sup. Tem. = Supratemporal. Tab. = Tabular.

There is a series of bones anterior to the frontals, the most prominent of which, is a large median element. It has been referred to as the ethmoid; but since it certainly contains the postrostrals, and probably the median rostral also, it is, perhaps, best referred to as the rostralo-postrostral. There does not appear to be space for an independent rostral element between it and the premaxillæ. The lateral rostrals may be free. The nasals are a pair of small bones which lie on either side of the ethmoid, and are in contact with the anterior border of the frontals.

The outer border of the parietals, and to some extent that of the first tabulars and the frontals, is met by the sinuous inner margin of the large supratemporal. The upper border of the orbit is formed by the pre- and postfrontals. The latter adjoins the anterior border of the supratemporal, and is in contact with the frontal throughout the whole of its length. The prefrontal has its inner border bounded by the frontal and nasal; its anterior border cannot be clearly distinguished. The premaxillæ are not revealed in any of the specimens. Below the postfrontal, and forming the upper angle of the posterior border of the orbit, is a postorbital bone. Behind this, and wedged between the supratemporal and upper border of the preoperculum, is a triangular-shaped element. Below the orbit there may be a series of narrow infraorbital bones.

The maxilla is essentially of Palæoniscid pattern: the posterior portion, which is much longer than the anterior portion in this genus, is massive and deep, and is in contact with the preoperculum along the whole of its dorso-posterior border. It is suddenly excavated anteriorly, and is very shallow below the orbit. In this region it is probably surmounted by a series of infra-orbital ossicles. It adjoins the premaxilla anteriorly. The preoperculum is similarly of Palæoniscid appearance, and consists of two shanks, one narrow, vertical, and posterior to the maxilla, the other horizontal, wide, and above the maxilla. The operculum is a fair-sized bone of roughly circular shape, but it is produced to an obtuse angle antero-dorsally. Wedged between its anterior margin and the posterior border of the preoperculum is a long narrow bone, presumably corresponding to Traquair's bone X. It is evidently a member of the opercular series, and not of the preopercular, for the preopercular sensory canal, which follows a course along the posterior border of the preoperculum, is in its normal position. The bone X cannot, therefore, be regarded as having been derived from the preoperculum. The suboperculum is about the same size as, or perhaps a little larger than, the operculum. It has a straight ventral suture with a smaller hemispherical plate which completes the opercular series. This latter bone does not correspond to the interoperculum, and, although its origin is a little uncertain, it is probably the modified first branchiostegal ray. True branchiostegal rays are absent. The mandible is long and stout, and, like the maxilla, is extensively ornamented with longitudinal ganoine ridges. Its dentigerous border is slightly curved; it is deep behind and gently tapers anteriorly. Both the maxilla and mandible bear numerous small, conical, and sharply-pointed teeth.

The Sensory Canals of the Head.

The heads of these fishes are very beautifully preserved, and the sensory canals, which are large and prominent, show up with striking clarity. The canals open outward to the surface in a series of tubuli, the external orifices of which are large and distinct. The course of the head-canals closely adheres to that displayed in the Palæoniscidæ. There is a supraorbital canal which pursues a slightly sinuous course in the frontal bone before passing anteriorly into the antorbital. Its forward extension from here could not be traced, and

although it is clearly apparent at the posterior border of the frontal, there is no definite indication that it extended into the parietal. There are, however, a series of pit-organs in the postero-lateral corner of the parietals, and immediately behind them there is another pair situated near the anterior border of the dermo-supraoccipitals.

The main branch of the sensory canal system comes up from the body and enters the supracleithrum. It runs first anteriorly and then dorsally in this bone, and reaches the tabular, where it runs straight forward through the tabular, supratemporal, and postfrontal almost up to the border of the orbit. In the tabular a branch is sent off toward the middle line; this canal passes right across the roof, and is the so-called "supratemporal commissure." The external openings of this branch are partially concealed by the backward extension of the dermo-supraoccipitals in the region of the mid-dorsal line. A second branch, the hyomandibular, is given off in the supratemporal. It passes below, keeping close to the posterior border of the preoperculum, and then extends into the mandible, where it runs along the posterior and ventral margins. The main sensory canal bends sharply down in the postfrontal and passes into the circumorbital bones, where it becomes the suborbital canal. Its forward extension and probable fusion with the supraorbital canal could not be traced.

Appendicular Skeleton.

The post-temporal is a smooth triangular-shaped bone with its apex reaching the mid-dorsal line. Its base overlaps the supracleithrum, which is a stout, highly-sculptured bone of quadrangular shape, ornamented by a series of uniform longitudinal ridges. The cleithrum is similarly sculptured, and is also a large element. There is a small postcleithrum lying behind the upper part of the cleithrum and in contact with the lower border of the supracleithrum. The clavicle is not well displayed in this species, but it occupies its usual position between the mandibles and overlapping the anterior extension of the cleithrum. The skeleton of the pectoral fin is made up of eight strong rays, certainly unjointed for a long distance proximally, but probably jointed toward their tips. There is an anterior fringe of large and numerous fulcra.

The pelvic is a small fin, consisting of about nine completely jointed rays. Fulcra are present, and are concentrated toward the tip.

The dorsal and anal fins are about the same size, and are similarly shaped. The fulcra are not conspicuous in either, and tend to be distally concentrated as in the pelvic fin. The dorsal has eighteen and the anal sixteen closely set and completely jointed rays.

The tail is hemiheterocercal; a scaly covering extending about half-way along the dorsal lobe. The lepidotrichia are very fine, very numerous, and jointed throughout their length. They number about sixty, and are very much finer on the dorsal lobe than on the median part or ventral lobe of the fin. Fulcra are not at all prominent, but they are present both dorsally and ventrally. They are extremely sparse on the outer border of the ventral lobe.

Squamation.

The scales are typically ganoid, fairly thick and rhombic in shape. The margins are entire, and ornamentation is lacking. They are a little deeper than broad in the neighbourhood of the lateral line, but the depth rapidly decreases ventrally, until, in the region of the pelvic fins, the width is three times as great

as the depth. Enlarged scales are present between the dorsal and caudal fins, and are probably also represented to some extent on the corresponding ventral surface.

Observations.

This species, which is represented by the most exquisitely-preserved material in the collection, is easily distinguished from the other members of the genus. Its slender form, backwardly-placed dorsal and anal fins, elongated, broad, dorsally-flattened head, and, viewed from the side, rather conical snout, all combine to impart a very characteristic appearance. The pectoral fin provides a more precise character by which it can be distinguished, this appendage having only eight stout, largely unjointed rays and numerous large fulcra.

HELICHTHYS STEGOPYGÆ, sp. n.

This species is represented in the collection by one slightly incomplete specimen (P. 12 D), which is evidently the remains of a small but well-proportioned fusiform fish. The caudal and anal fins are imperfect, and the pelvics are altogether lacking. The fins are of moderate size; the dorsal and anal are opposite, and both are placed far back on the body, well within the posterior half. The orbit is large and anteriorly placed. The gape is wide and suspensorium oblique.

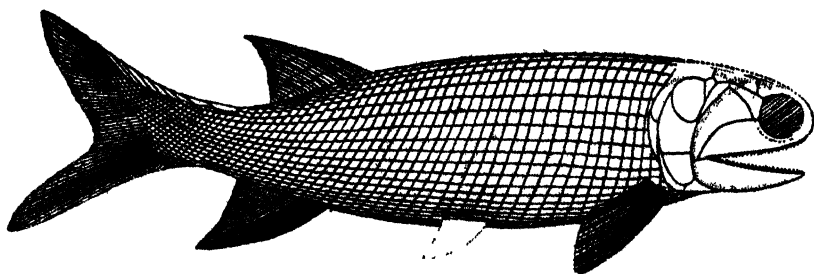
Dimensions :—

| | |
|----------------------|---------|
| Total length | 105 mm. |
| Greatest depth | 22 „ |
| Length of head | 23 „ |

Head.

In this specimen the bones of the cranial roof and of the snout are not well preserved, but the region of the cheek and jaws can be fully reconstructed. The bones which are present are very extensively ornamented with numerous well-defined ganoine ridges.

Text-figure 6.



Restoration of *Helicthys stegopygæ*, sp. n. Natural size.

Drawn from the type-specimen (P. 12 D).

The most dorsally-placed element which is distinctly visible, is the large, roughly rectangular supratemporal. Anteriorly its lower border adjoins a single large postorbital which forms the posterior margin of the orbit, and comes into contact with the preoperculum below. The posterior part of the ventral border of the supratemporal abuts against two small bones of the

opercular series X and X'. These are tucked in between the operculum and the preoperculum, but are posterior to the preopercular sensory canal. The operculum is a small bone of scarcely half the size of the suboperculum. The latter is large and prominent, and is the most important element in the opercular apparatus. The opercular series is completed by the modified first branchiostegal, which is a comparatively large plate fitting the lower border of the suboperculum perfectly, and being united to that bone by a straight suture. Normal branchiostegal rays are absent.

Although they occupy approximately the same total area, the preoperculum and maxilla display a different relationship to that in the previous species, and in this respect tend to recede from the Palæoniscid type. The two shanks of the preoperculum are not distinct, the inferior border being gently curved and not angular. The cutting off of this angle adds to the width of the preoperculum and diminishes the depth of the maxilla at its posterior end. Thus, there is no truly posterior border to the maxilla, it being bounded by a postero-dorsal line, and consequently the greatest depth of the maxilla is not posterior but median. The maxilla is sharply excavated in front and is very shallow below the orbit, as in all other species of the genus, and, indeed, of the family. The mandible is large and stout, and, like the maxilla, bears a large series of small, sharply-pointed teeth.

Little of the sensory canal system can be discerned. The line of the main canal is seen obliquely in the rectangular supracleithrum, and again running straight through the supratemporal. In the latter bone the preopercular branch is given off, and its course through the preoperculum and mandible is easily visible.

Appendicular Skeleton.

The membrane bones of the pectoral girdle are large and well developed. Supracleithrum, cleithrum, postcleithrum, and clavicle are present, and all are well ornamented with longitudinal ganoine ridges. The post-temporal is a large element, but its boundaries are a little indistinct in this specimen. The dermal rays of the fin number about twenty; the anterior members are comparatively coarse and unjointed for a long distance proximally, but merge posteriorly into very fine rays, jointed throughout their length. Fulcra are absent.

The pelvic fins are not preserved in this specimen, but their position on the body is apparent.

The dorsal fin is triangular and rather pointed at the tip, and consists of twenty-five completely jointed rays. Fulcra are very weakly developed, and, as in the other species of the genus, are distally situated on the fin-margin.

The skeleton of the anal appendage is constituted by at least thirty-four jointed rays. As the anterior border of this fin is imperfect, it is impossible definitely to determine whether or not fulcra were present. From a consideration of the condition of the fins in related species it seems probable that this fin was exactly comparable in structure with the dorsal, and displayed a correspondingly weak development of fulcra.

The caudal fin is hemiheterocercal, with the scaly lobe extending nearly half-way up to the tip. There are sixty-five fine, completely jointed rays. The finest of these occur dorsally and ventrally, those medianly placed are comparatively coarse. Fulcra are present on the dorsal ridge.

Squamation.

The scales are thick, smooth, rhombic, and ganoid, and possess perfectly smooth margins. They are comparatively large, and at their maximum

development deeper than broad, those on the flank, in the sixth row behind the head, measuring $2\frac{1}{2} \times 1\frac{1}{2}$ mm. They decrease in size posteriorly and lose their depth, those below the dorsal fin being about as deep as broad. The scales of the caudal lobe are very much reduced in size, very numerous, and lozenge-shaped. Between the dorsal and anal fins there are twenty-two scales in a vertical row, and from the commencement of the tail to the shoulder-girdle there are thirty-four rows. The tail-pedicle bears very prominent ridge-scales dorsally, and smaller ridge-scales were present on the ventral surface.

Observations.

The most obvious distinguishing characters of this species are : the presence of two small bones between the operculum and preoperculum ; only one postorbital bone ; the lack of fulera on the pectoral fin ; and the large number of fine rays (twenty) in that appendage.

The preoperculum and maxilla, as indicated above, depart further from the Palæoniscid type in this than in any other species of the genus. The cutting-off of the dorso-posterior angle of the maxilla adds considerably to the width of the preoperculum, and tends to straighten out the preopercular-maxillary suture, giving an appearance similar to that displayed by the higher genera of the Catopteridæ.

HELICHTHYS OBESUS, sp. n.

There are two specimens of this species lying together on the same slab (P. 12 B & C). They are approximately the same size. The fins are small, the caudal particularly so, and along with the short bullet-like head and stumpiness of the body impart an ungainly appearance to the fish. The dorsal and anal fins are triangular in shape and are about opposite ; the dorsal is just a little in advance of the anal. The pelvic is not preserved, but was, presumably, nearer to the anal than to the pectoral fin. The gape is moderately wide, and the suspensorium oblique. The orbit is very anteriorly placed.

Dimensions :—

| | |
|----------------------|--------|
| Total length | 85 mm. |
| Greatest depth | 20 " |
| Length of head | 19 " |

Head.

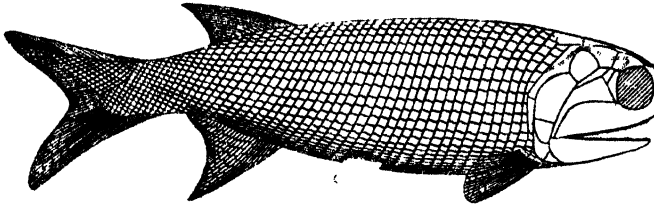
Although it possesses the same elements in the skull, this species differs markedly from the others in the peculiar shortness and bluntness of the head, and particularly in the fact that the membrane-bones of the skull are smooth and lack ornamentation of any sort.

The shortening of the skull is particularly apparent dorsally, and there is a consequent shortening of all the dorsal elements. The median bones of the cranial roof are not preserved, but the supratemporal and postfrontal lose the long narrow character which they possess in the other species, and become almost as deep as broad. Another result of this shortening is that the operculum is carried anteriorly and closer to the orbit. Thus it takes up a different position to that seen in any other species of *Helichthys*, and tends to lie rather above than behind the preoperculum. In this situation it is reminiscent of the Palæoniscids.

There is only one small bone X between the operculum and the preoperculum. There is a second postorbital element between the postorbital and the bone X.

The whole opercular apparatus is small and appears to be inadequate and in life must have been supplemented by a membrane. The sub-operculum is much the largest element; it has a small operculum above and a smaller, modified branchiostegal below. The two shanks of the pre-operculum are well defined, and the maxilla is of normal type, very broad and

Text-figure 7.

Restoration of *Helicthys obesus*, sp. n. Natural size.

Drawn from the specimens P. 12 B and P. 12 C.

deep behind and very shallow below the orbit. The mandible is only moderately deep and is uncurved; both upper and lower borders are quite straight, and it tapers gently to the anterior end. Mandibles and maxillæ bear a large number of small, sharply-pointed teeth.

As much of the sensory canal system as can be distinguished conforms with the general arrangement possessed by the other species of the genus.

Appendicular Skeleton.

The membrane-bones of the pectoral girdle differ from those of the skull in the possession of a well-developed ornament of longitudinal ganoine ridges. The post-temporal is not very distinct, but there is indication that it is a large element. The supracleithrum is a comparatively massive bone; the post-cleithrum, cleithrum, and clavicle are similar to those described in previous species. The pectoral fin consists of about eighteen very fine rays which are unjointed proximally. The more posterior rays show a greater number of articulations. Fulcra are absent.

The pelvic fin is not preserved in either of the specimens.

The dorsal is a triangular-shaped fin, produced to a point distally, and is made of twenty-two fine, completely jointed rays. Fulcra are very inconspicuous, but a few are present near the tip.

The anal is similar to the dorsal fin, but is a little larger and has twenty-eight rays.

The tail is hemiheterocercal, with the scaly lobe extending rather more than half-way up to the tip. There are sixty-five completely jointed rays. Fulcra are present on the dorsal surface.

Squamation.

The scales are rhombic and ganoid, and articulate by a peg-and-socket arrangement. There are twenty in the row immediately before the dorsal fin and thirty-four rows on the body, counting from the first ventral lepidotrich of the tail. At a glance they appear to be smooth and unornamented, but closer examination reveals two small denticulations on the posterior margin of the undamaged scales, and two very faint ridges on the surface. They are

of moderate size; on the lateral and dorsal surfaces they are as deep as broad, and a few rows behind the head they measure 1.5×1.5 mm. The depth of the scales rapidly decreases toward the mid-ventral line, where they are closely packed, and appear to be long and narrow. There is an enlarged scale before the dorsal and anal fins. Ridge-scales are prominent on the dorsal aspect of the tail-pedicle, and are probably also present on the ventral surface.

Observations.

The chief peculiarities of this species are the shortness and bluntness of the head and complete lack of ornamentation on the cranial and jaw bones. Those characters provide a ready means of distinguishing it from the other species of *Helicthys*. Along with these may be mentioned the presence of a second postorbital, of only one bone X between the operculum and preoperculum, and of a pectoral fin with eighteen very fine partially jointed rays.

HELICHTHYS CTENIPTERYX, sp. n.

The only material representing this species is one imperfect fish in counterpart (P. 11 A and P. 12 A), which lacks the tail, the posterior part of the body, and the dorsal fin. The fins which are present are of moderate size; the pelvis are about midway between the anal and the pectorals. The gape is wide and suspensorium oblique. The orbit is large and anteriorly placed.

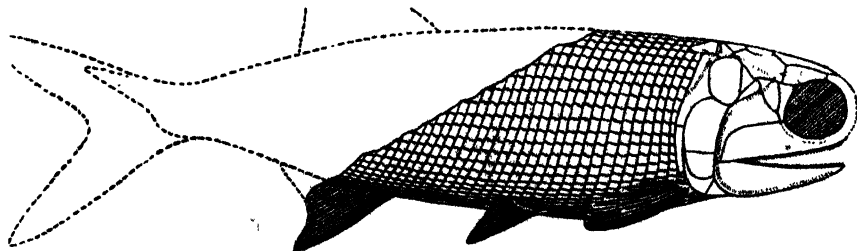
Dimensions (approx.) :—

| | |
|----------------------|---------|
| Total length | 100 mm. |
| Greatest depth | 24 „ |
| Length of head | 24 „ |

Head.

The structure of the head is remarkably well revealed, and is almost identical with that of *H. elegans*. With one exception, the presence of a second small bone between the operculum and preoperculum in this species, precisely the

Text-figure 8.



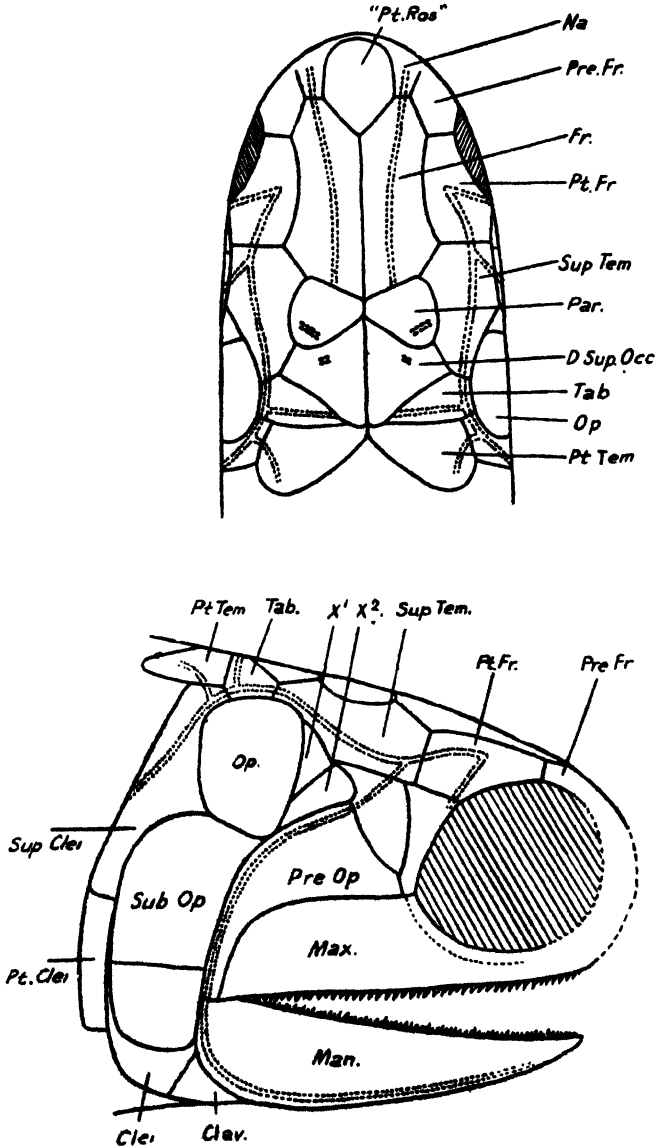
Restoration of *Helicthys ctenipteryx*, sp. n. Natural size.

Drawn from the type-specimen (P. 12 A).

same elements enter into the constitution of the skull in both. The position of the bones in relation to one another is also the same, but there is a difference in proportion in the individual bones.

This is accounted for by the fact that the head in *H. ctenipteryx* is not so elongated as in *H. elegans*, and consequently the individual bones tend to be

Text-figure 9.



Helicthys ctenipteryx, sp. n. Restoration of the head. $\times 3$.

For key to lettering, see text-fig. 5.

relatively shorter and broader. A comparison of the frontals in the two forms fully illustrates the point; the ratio of length to width being 3.5 : 1 in *H. elegans*

and 2.5:1 in *H. ctenipteryx*. The same applies to all the other bones of the cranial roof, and is well seen in the supratemporal and postfrontal. These latter bones are of very similar shape and have exactly the same relations to the surrounding elements, but they are much broader, and lack the elongated appearance which characterizes the homologous bones in *H. elegans*.

The head of *H. ctenipteryx* is also relatively higher than that of *H. elegans*, and this, along with the decreased length of the skull, accounts for differences in the shape and proportions of the cheek-bones. The operculum is narrow and high, not squarish, as in *H. elegans*. There are two X-bones, and in front of these two postorbitals. There are also two postorbitals in *H. elegans*, but in the latter species they are long and not high, while in *H. ctenipteryx* they are both a good deal higher than long. The suboperculum shows corresponding characters in the two species, for it is about as wide as high in *H. elegans*, whereas it is nearly twice as high as wide in *H. ctenipteryx*. Similarly with the modified branchiostegal, it is wider than high in *H. elegans*, and about as wide as high in *H. ctenipteryx*. Thus the effect of this change of shape of the head on the opercular apparatus has been to decrease the width and elongate the series.

The preoperculum is in two shanks, the upper of which is high and wide. The maxilla is deep behind and shallow in front. The mandible is fairly deep posteriorly and gently curved. Upper and lower jaws bear a numerous series of small, sharply-pointed, conical teeth.

The sensory canals of the head follow a precisely similar course to that seen in *H. elegans*, and pit-organs are similarly situated. There is, however, one branch shown in this species which could not be clearly discerned in *H. elegans*. This is a small branch which leaves the main canal in the supracleithrum, and passes first upward through the post-temporal, and then backward on to the dorsal surface of the body, where it dies out.

Appendicular Skeleton.

The shoulder-girdle is composed of large and well-ornamented supracleithrum, cleithrum, postcleithrum, and clavicle. There are seven, apparently, unjointed and unbranched rays in the skeleton of the pectoral fin. They are fringed anteriorly by large fulcra.

The pelvic fin is small and triangular, and has twelve rather fine completely jointed rays. There is a weak development of fulcra distally.

The dorsal fin is not preserved.

The anal is an incomplete fin of triangular shape with twenty-one completely jointed rays. The total number of rays was probably thirty when complete. Fulcra are quite inconspicuous, but they are present toward the tip of the fin.

The caudal fin is not preserved.

Squamation.

The scales are of moderate size, measuring 1.75×1.75 mm. in the region of the lateral line, six rows behind the head. In this area they are as deep as broad, but they become very shallow on the ventral surface. They lack surface ornamentation, but undamaged scales exhibit a faint denticulation of the posterior margins. There are enlarged scales before the pelvic fin and around the anal opening.

Observations.

This species differs sharply from *H. stegopyga* and *H. obesus* in the nature of the pectoral fin. It has a similar type of pectoral fin to *H. elegans* and

H. grandipennis, but is distinguished from *H. elegans* by the possession of a much greater number of rays in the pelvic and anal fins. A more detailed comparison with *H. grandipennis* will be given under the description of that species.

HELIOTHYS GRANDIPENNIS, sp. n.

The specimens P. 14 and P. 24 represent an imperfect fish in counterpart lacking the tail and part of the head.

The body is fusiform, and tapers sharply to a very narrow tail-pedicle. The dorsal fin is posteriorly placed and is directly opposite the anal; the pelvics are midway between the pectorals and the anal. The gape is wide and suspensorium oblique.

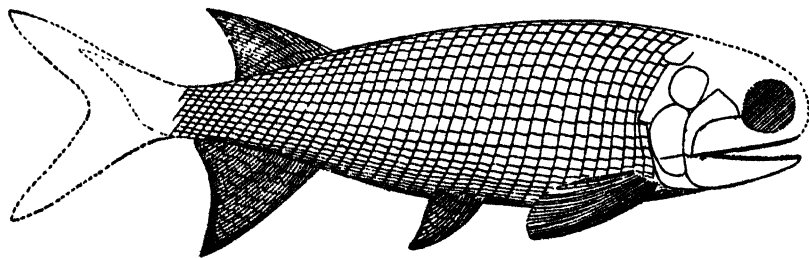
Dimensions (approx.) :—

| | |
|----------------------|---------|
| Total length | 105 mm. |
| Greatest depth | 25 " |
| Length of head | 24 " |

Head.

The bones of the cranial roof and snout are lost. Only those of the jaws and opercular apparatus are present, and all are prominently ornamented with ridges and tubercles of ganoine. The operculum is small and almost circular in shape, and below it there is a larger and more quadrangular suboperculum. The modified first branchiostegal is not well preserved. The preoperculum is large and strongly curved: the lower border, that in contact with the maxilla,

Text-figure 10.



Restoration of *Heliothys grandipennis*, sp. n. Natural size.

Drawn from the type-specimen (P. 14).

is almost in the form of a right angle. The maxilla is very broad behind, and shallow anteriorly below the orbit. The mandible is very strong and is deep posteriorly, but it tapers gently to the anterior end. Like the maxilla, it has a large series of very small, sharply-pointed, conical teeth. The course of the mandibular sensory canal is very clearly seen in this specimen.

Appendicular Skeleton.

The shoulder-girdle is complete and well displayed, and the individual bones are large, stout, and extensively ornamented. The post-temporal is a large triangular element with the apex toward the middle line as in *H. elegans*. The base overlaps a supracleithrum, which is of regular, quadrangular shape.

The largest element in the girdle is the cleithrum, which has a vertical shaft adjoining the supracleithrum, and a horizontal shaft which is overlapped by the clavicles. There is no distinct postcleithrum.

The pectoral fin has twelve stout, unbranched, and apparently unjointed rays, but it is likely that at least the more posterior ones are jointed toward their distal extremities. There is a prominent fulcral fringe anteriorly. The base of the fin is constricted.

The pelvic is a broad-based triangular fin with sixteen completely articulated rays. Small fulcra are present toward the tip of the fin, but they are quite inconspicuous.

The dorsal fin is rather low and is pointed at the tip; it is made up of twenty-two completely jointed rays. Fulcra are present toward the tip, but, as in the pelvic and anal, they are by no means prominent, and can be easily overlooked.

The anal fin is large and triangular, and consists of over thirty-five completely jointed rays which display a thread-like branching distally.

The caudal fin is not preserved.

Squamation.

The body is covered by a series of thick, rhombic, ganoid scales. The largest scales, those on the anterior flank just behind the head, are deeper than broad, measuring 2×1.5 – 1.75 mm. These large scales have also a denticulated posterior margin, and certain of them show traces of oblique striation, but such are very rare. Generally the surfaces are smooth, and the borders of the dorsally, ventrally, and posteriorly placed scales are entire. In most of the species of *Helichthys* the scales are smooth, and the trace of ornamentation present here suggests that the ancestor of *Helichthys* possessed ornamentated scales, but that in a progressive evolution this character has been almost completely lost. The ventral scales are very shallow, as in all the other species of *Helichthys*. The dorsal scales do not lose their depth to the same extent. There is a marked decrease in the size of the scales posteriorly, and those on the tail-pedicle are less than 1 mm. square. There are twenty scales in a row between the dorsal and anal fins, and about thirty-eight rows on the body.

Observations.

This fish bears a strong general resemblance to *H. ctenipteryx*, and is in many respects identical. It agrees in the general form, ornamentation of the head, shape and disposition of the head-bones, nature of the fins, and in the possession of moderate-sized scales, sometimes with a faintly pectinated posterior border. It appears to differ from *H. ctenipteryx* in two respects:—

1. The pectoral fin, while being of the same type as *H. ctenipteryx*, has eleven rays, with the more posterior members of the series showing traces of distal jointing.

2. The fins are comparatively much larger. The two fishes under comparison are of approximately the same size, but the fin-measurements are as follows:—

| | <i>H. ctenipteryx.</i> | <i>H. grandipennis.</i> |
|--------------------------|------------------------|-------------------------|
| Length of pectoral | 11 mm. | 18 mm. |
| Length of pelvic..... | 9 " | 13 " |
| Length of anal | 11 " | 20 " |

These differences are too great to be explained as individual variations, and the two specimens must be looked upon as representatives of different species. Were the specimens more complete, it is very probable that further differences in structure would be revealed.

Fam. PERLEIDIDÆ.

Fishes usually of small size; body elegantly to deeply fusiform in most forms, but becoming exceedingly deep and laterally flattened in certain genera. Width of gape variable, commonly moderate. Suspensorium usually straight, but may be a little forwardly or backwardly inclined. Orbit moderate or rather large in size; anteriorly situated. One dorsal fin present; pelvic fins abdominal.

External bones of the skull smooth or ornamented. Frontals very large, forming the major part of the cranial-roof; parietals large and almost invariably square, although they are thickly quadrangular in one or two species; dermo-supraoccipitals absent. Supratemporal long and narrow; intertemporal present between the supratemporal and the postfrontal. Nasals large, forming part of the orbital border. Maxilla large and massive; it is triangular in shape, with the greatest depth about the middle; posterior border gently curved, and in contact with a large preoperculum which is expanded above and narrow below. Mandibles variable in size; often moderately stout, but becoming weak and shelf-like in certain genera. Teeth commonly cylindrical and peg-like, but may be completely absent. Operculum usually smaller than the suboperculum; interoperculum not developed; branchiostegal rays large and prominent. Sensory canals of the head follow the Palæoniscid pattern closely; there is no anastomosis between the supra-orbital and infra-orbital canal.

Membrane-bones of the shoulder-girdle rarely massive; clavicles usually inconspicuous. Dermal fin-rays coarsely branched, equalling in number the endoskeletal supports. Rays of the paired fins always more or less fused; those of the dorsal and anal fins fused proximally and articulated distally. Tail hemiheterocercal; scaly lobe always very short. Body with a covering of thick ganoid scales which may be ornamented with striæ or granules; posterior borders often denticulated.

Genus MEIDICTHYS, nov.

Body small; fusiform. Head short and blunt, the large, almost flat "ethmoidal" plate being vertically placed on the end of the snout. Gape moderate; suspensorium slightly forwardly directed. Skull-bones perfectly smooth. Frontals very large and regularly shaped, but wider behind and slightly narrowed between the orbits; parietals large and square; tabulars narrow and inconspicuous; supratemporal rather long but very narrow; intertemporal small. Snout covered by a large, medianly placed, rostralo-postrostral; a pair of nasals lie on either side of this bone and extend to the orbit. Two supraorbital ossicles occur between the pre- and postfrontals. Operculum and suboperculum together forming one continuous quadrangular opercular plate; operculum smaller than suboperculum; a series of branchiostegal rays commence below the suboperculum. Preoperculum large and expanded above, but narrowing gently to a point below. Maxilla triangular, with its apex situated just behind the orbit; posterior margin steep and slightly curved; anterior margin sloping more gradually. Mandible moderately stout, tapering uniformly to the anterior end; upper border gently curved. Maxillæ, premaxillæ, and mandibles bearing large peg-like cylindrical teeth. Unpaired

fins moderate in size ; paired fins small ; dorsal opposite the space between the anal and pelvics ; pelvics nearer the anal than the pectorals. Dermal fin-rays corresponding in number to the endoskeletal supports. Rays in the pectorals, pelvics, dorsal, and anal fins stiff and unjointed for about half of their length proximally ; rays of the dorsal and anal fins distally branched ; rays of the caudal jointed throughout, but extensively branched. Tail hemiheterocercal, with a much abbreviated scaly lobe. Fulcra present on all fins. Scales deeper than broad, large and smooth ; posterior margins serrated.

This genus differs quite markedly from most of the other members of the family. To mention only the most characteristic points, it is distinguished from *Hydropessum* and *Cleithrolepis* by the shape of the body, from *Meridensia* by the different shape of the maxilla, from *Dollopterus* by the much smaller pectoral fin, from *Colobodius* by the shape of the body, and from all of these by the nature of the squamation.

When it is compared with *Perleidus* (Stensiö, 1921) it is found to resemble this genus in the shape of the body, the character and disposition of the fins, the nature of the squamation, and the structure of the skull. There is no doubt that the two forms are nearly related, but that they are distinct genera is indicated by the differences tabulated below :—

1. The head in *Meidiichthys* is of very different shape to that of *Perleidus* ; it is not pointed, but flattened at the snout. The rostralo-postrostrals are preserved uncrushed in both genera, and display a very different shape ; that of the Spitzbergen fish *P. woodwardi* being not flat, but sharply bent, to give the anterior point to the snout.

2. The membrane-bones of the skull are perfectly smooth in *Meidiichthys* ; in *Perleidus* they are sculptured.

3. The suspensorium is directed slightly forward in *Meidiichthys* ; in *Perleidus* it is directed slightly backward, and the gape is somewhat wider.

4. The suboperculum is relatively larger in *Meidiichthys* than in *Perleidus*.

There are other minor differences, but they are not of generic value.

MEIDIICHTHYS BROWNI Broom.

This is one of the commonest species in the Bekker's Kraal fauna, and is represented in the collection by abundant material (P. 20, P. 7 A, P. 23, P. 21 A, P. 22 A, P. 6 B, P. 15 B, P. 15 C). These specimens are of small fusiform fishes with small blunt heads. The fins are of moderate size ; the dorsal is opposite the space between the pelvic and the anal, and the pelvic is nearer the anal than the pectoral. The gape is fairly wide, and the suspensorium is straight, or perhaps forwardly directed. The orbit is large and anteriorly placed. The individuals vary in length from about 65 to 100 mm. ; the measurements given below are of P. 20, one of the larger specimens :—

| | |
|----------------------|--------|
| Total length | 96 mm. |
| Greatest depth | 20 " |
| Length of head | 18 " |

Head.

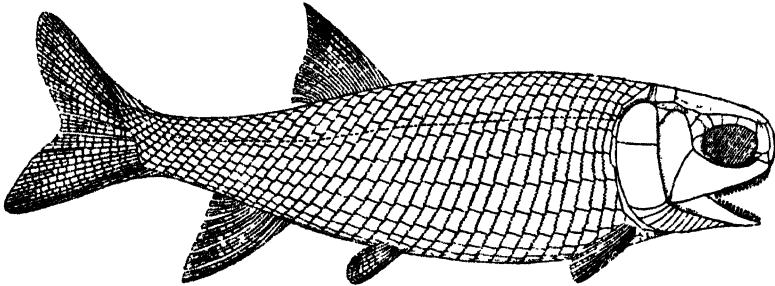
The membrane-bones of the skull are thin and perfectly smooth. The frontals are particularly large, and with the parietals cover almost the whole of the skull-roof. They are roughly rectangular, but are slightly narrower in

front, between the orbits, than behind. The long suture between them is wavy and interdigitating. The posterior border is straight and square, and abuts against the parietals. The lateral margin adjoins the supratemporal and intertemporal posteriorly, and in front is in contact with the pre- and postfrontals and the supraorbital ossicles. The frontals are bordered anteriorly by the upper margin of the nasals and the rostralo-postrostral.

The pattern of the skull-roof is very regular; the parietals are almost perfectly square, and their width corresponds exactly with that of the frontals. They are bordered posteriorly by the tabulars, and laterally by the supratemporal. The outlines of the tabulars are not easily distinguished, but there appears to be a single pair of long narrow bones lying behind the parietals, and each extending from the middle line to the top of the operculum.

This extensive development of roofing-bones seems to have taken place at the expense of the temporals. The supratemporal is small and quite narrow, and lies between the opercular bones below and the parietal and frontal above. It adjoins the intertemporal anteriorly, and this latter element is also small, and lies wedged between the supratemporal and the circumorbital bones.

Text-figure 11.



Restoration of *Meidiichthys browni* Broom. Natural size.

The restoration is based mainly on the specimen (P. 20), but for details of the head P. 7 A was also used.

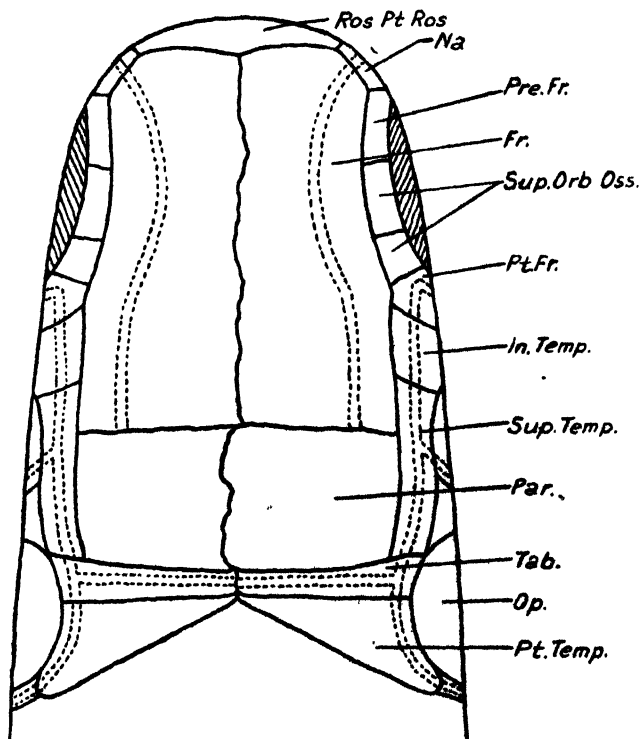
A fairly large number of bones come into the circumorbital ring. There is a large postfrontal dorsally, lying immediately in front of the intertemporal and the preoperculum. There is also a prefrontal adjoining the anterior part of the lateral margin of the frontal; and between these there are two supra-orbital ossicles, with their ventral margins free in the orbit and their dorsal margins meeting the frontal. The postorbital is in contact with the post-frontal, preoperculum, and the upper part of the maxilla; it is expanded and curiously rounded dorso-posteriorly, and it becomes very narrow anteriorly, where it meets a similarly narrowed jugal which is resting on top of the maxilla and adjoining a small lachrymal in front. The anterior border of the orbit is completed by the large nasal which comes in between the prefrontal and the lachrymal.

Between the paired nasals there is a large median element which forms the principle covering of the snout. This corresponds to the bone usually called ethmoid, but the name rostralo-postrostral is used here. It is gently convex, and is a shield-like bone which in life was in a vertical position. It extends from the anterior border of the frontals down to the premaxilla, and is bordered laterally by the nasals above and a small pair of lateral rostrals

below. These latter bones are small, but each is in contact with the lachrymal, nasal, rostralo-postrostral, maxilla, and premaxilla.

The operculum and suboperculum make a firm and close contact with one another, and form one continuous opercular plate of roughly quadrangular shape but with the upper border gently rounded. When the suture between them has been located it is found that the operculum is much smaller than the suboperculum. There is a large preoperculum in front, which covers most of the cheek and extends forward close to the border of the orbit. It is expanded

Text-figure 12.



Meiodictyus browni Broom. Restoration of the head, dorsal aspect. $\times 4$.

Fr.=Frontal. In.Temp.=Intertemporal. Na.=Nasal. Op.=Operculum. Par.=Parietal.
Pt.Fr.=Postfrontal. Pt.Temp.=Post-temporal. Pre.Fr.=Prefrontal. Ros.-pt.Ros.=
Rostralo-postrostral. Sup.Orb.Oss.=Supraorbital ossicles. Sup.Temp.=Supratemporal.
Tab.=Tabular.

above, but narrows almost to a point ventrally, where it is gently excavated for the backward extension of the maxilla. The suture between the preoperculum and the maxilla is gently curved. Between the operculum and preoperculum, and in contact with the supratemporal, there is a small bone X which is a member of the opercular series. There is no interoperculum; the suboperculum is followed directly by a conspicuous series of large branchio-stegal rays.

The maxilla is a massive element of approximately triangular shape. It is highest just behind the orbit, and shallows rapidly behind and more gently

in front. The mandible is of moderate size, fairly deep behind, and tapering uniformly anteriorly. The upper margin is gently curved. The dentition is peculiar, consisting, as it does, of a comparatively small number of long, cylindrical, and bluntly-rounded teeth. There are about a dozen on each maxilla and mandible.

The Sensory Canals of the Head.

The sensory canals run inside the bones of the head, and open to the exterior by numerous small, inconspicuous, and irregular pores. The bone over the canals is, however, so very thin that it frequently breaks down, and in the fossils the canals appear as wide-open grooves.

The course pursued by the canals is exactly similar to that in *Helicthys* and the Palæoniscids. The main canal comes up from the body, and passes through the supracleithrum and post-temporal to the tabulars, where it gives off a branch at right angles which meets a similar one from the other side and forms the supratemporal commissure. The main canal goes forward through the supratemporal and intertemporal into the postfrontal, where it turns down as the infraorbital canal and passes through the postorbital and jugal. The hyomandibular branch is given off in the supratemporal and runs the length of the preoperculum, always keeping close to the posterior border. It then enters the mandible, where it passes from the posterior to the anterior end along the ventral margin.

A supraorbital canal arises at the extreme posterior end of the frontal, and passes forward, traversing the complete length of this bone before passing into the nasal. Its course in the nasal cannot be distinctly traced, but there is little doubt that it anastomoses with the infraorbital canal and gives off a branch across the rostralo-postrostral. The pit-organs of the parietal are also indistinct.

Appendicular Skeleton.

The membrane-bones of the pectoral girdle are not strongly developed, and in most of the specimens they are a little obscure. Immediately behind the tabular there is a triangular-shaped post-temporal with its apex toward the middle line. It articulates below with a rather short quadrangular supracleithrum, and the latter is in contact with a large cleithrum. Clavicles are not distinctly visible in any of the specimens, but they are probably present, hidden beneath the large branchiostegals, which are usually squashed outwards. A postcleithral scale is present.

The pectoral is a small fin with a constricted base, and has at least five stiff rays which show traces of jointing distally. There is a prominent fringe of comparatively large fulcral scales.

The pelvic is similarly small and constricted, and is made up of about six distally-jointed rays which are branched at the extremities. Fulcra are present on the anterior edge of the fin, but only toward the tip.

In the dorsal fin the fourteen rays are stout, and are fused for a certain distance proximally; distally they are jointed and branched. Fine fulcra are present on the anterior margin, but, as in the pelvic and anal, are only developed away from the base.

The anal is in an exactly similar condition to that of the dorsal, but consists of only eleven rays.

The tail is of moderate size and is not deeply forked. It is hemiheterocercal, with a scaly lobe which extends no more than a quarter of the distance toward

the tip. The fin is made up of twenty-two rays which are comparatively very coarse. They are widely interspaced and much branched in the median region, and finer, more closely packed, and less branched dorsally and ventrally. They are all completely jointed, and the branching is conspicuous. Fulcra are developed on both dorsal and ventral margins.

Squamation.

The body is covered by thick ganoid scales of fairly large size. On the anterior flanks they are twice as deep as broad, and in the rows immediately behind the head in P. 20 they measure 4×2 mm. They decrease in depth both dorsally and ventrally, but not to the same extent as in Palæoniscids and the primitive Catopterids. They also decrease in size posteriorly, and on the tail-pedicle they are as deep as broad, measuring 1×1 mm. The surfaces of the scales are perfectly smooth, but the posterior margins are finely pectinated. There are about ten scales in a row in the area beneath the dorsal fin and thirty-four rows on the body, counting forward from the first lepidotrich in the ventral lobe of the tail.

Genus *CLEITHROLEPIS* Egerton (1868).

The name *Cleithrolepis* was applied by Sir Philip Egerton to an imperfect fish found in the Hawkesbury Series at Cockatoo Island, N.S.W. For many years this remained the only record of the genus, but in 1888 Smith Woodward described a deep-bodied Ganoid from the Upper Beaufort beds at Bekker's Kraal, Rouxville, O.F.S., South Africa, and decided that it was a species of the Australian genus *Cleithrolepis*. In 1890 Smith Woodward described a large collection of fossil fishes from the Hawkesbury Series of New South Wales, in which one of the commonest forms was *Cleithrolepis*. It was liberally figured in that monograph, and a restoration was given. In 1908 the same author briefly noticed the occurrence of *C. granulatus*, the type-species, in a collection from St. Peter's, N.S.W. In the following year Broom examined the South African material more fully, and founded a new species, *C. minor*.

Owing in some cases to the scarcity and in others to the badly-preserved nature of the material, the earlier descriptions give little beyond the general form of the body, the disposition of the fins, and the nature of the squamation. Broom added a precise description of the fins, and emphasized certain skull-characters, the most important of which was the large and expanded nature of the preoperculum.

The large amount of material which I have at my disposal allows me to give a more complete description of this genus than has hitherto been published. In Prof. Watson's collection there are sixteen specimens, with seventeen individuals of *Cleithrolepis*. There is one specimen of *C. exoni* which, unfortunately, only displays the posterior part of the body. All the other individuals are *C. minor*. The accompanying restoration was constructed from P. 1 A & B, P. 29 A; P. 30, P. 31, P. 32, P. 33, and P. 34, which are mostly fairly complete fishes.

Generic Definition.

Body extremely deep; nearly as deep as long. Head deep, short, and blunt; snout pointed. Gape narrow; suspensorium straight. Orbit fairly large. Unpaired fins backwardly placed; well within the posterior third of the body. Paired fins small; pelvics lying about midway between anal

and pectorals. Frontals very long and very wide; forming almost the whole of the covering of the cranial roof. Parietals large, wider than long, and almost rectangular. Temporal bones exceedingly narrow and sinuous, reduced to the minimum that will carry the main sensory canal of the head. Supratemporal and intertemporal both elongated, stretching from the post-temporal to the postorbital. Opercular apparatus very prominent. The opercular shield formed by the operculum and suboperculum is deep and crescentic. Preoperculum very deep and fairly wide except below, where it is in contact with the maxilla. There is a series of about six circumorbital ossicles. Maxilla large and triangular; posterior margin firmly united to the large preoperculum. Mandible very weak and shelf-like. Dentition absent. Branchiostegal rays weak. Sensory canals of the head distinct; they conform to the Palæoniscid pattern. Number of rays in the fins coincides with the number of internal supports except at the anterior edges of the unpaired fins, where the rays are concentrated and more numerous. All fin-rays completely articulated, and those of the unpaired fins coarsely branched. Tail hemiheterocercal, with a very short scaly lobe. Scales thick, narrow, and very deep, ornamented by numerous small irregularly-placed tubercles.

CLEITHROLEPIS MINOR Broom (1909).

The body is about as deep as long, but the depth is only about two-thirds of the total length of the fish. The head is short, deep, and blunt. The gape is small and the suspensorium is straight. The orbit is comparatively large. The dorsal and anal fins are about equal in size; they are directly opposite, and are very posteriorly placed, their finer rays being almost on the tail-pedicle. The paired fins are small. The pelvics lie about midway between the anal and the pectorals. This is the smallest species of the genus, and has the following average dimensions:—

| | |
|----------------------|--------|
| Total length | 61 mm. |
| Greatest depth | 39 „ |
| Length of head..... | 13 „ |

Head.

The surfaces of the bones are generally smooth, but some few exhibit a faint granulation. The bones are very thin, and the sutures between them extremely close. The skull-roof is made up principally of a very large pair of frontals which are wide behind but somewhat narrowed between the orbits. The parietals are of fair size and are a good deal broader than long. They tend to be quadrangular, but the inner border is shorter than the outer one. The suture between them is very irregular. Behind the parietals there is a narrow tabular row which probably consists of a single pair of bones.

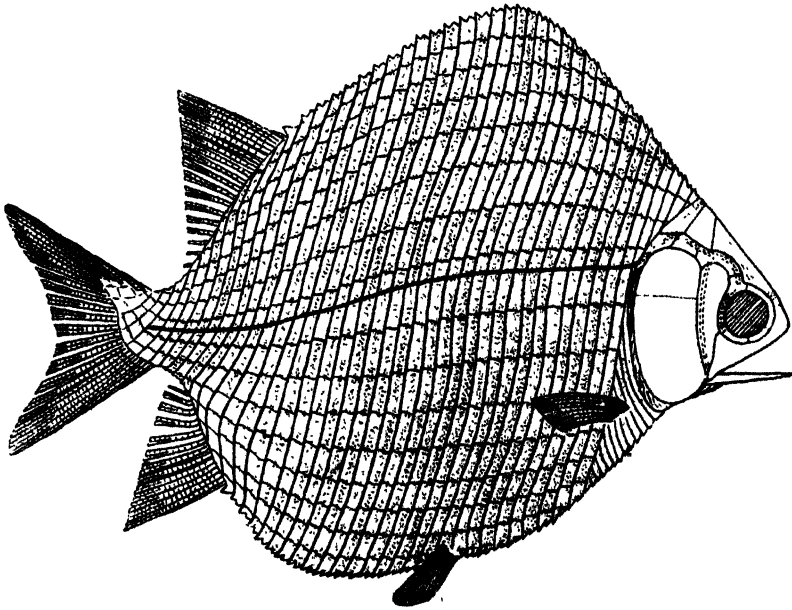
The space between the roof-bones and the cheek is exceedingly narrow, and is filled in by a wide post-temporal and a supratemporal and intertemporal, both much elongated. The opercular apparatus is very conspicuous, and is preserved in most specimens. There is a large, slightly crescentic plate made up of a small operculum and a large suboperculum. The suboperculum is very much the larger of the two. The front margin of this plate is articulated along its entire length with the preoperculum. The latter is a large bone, rather expanded above, but narrowed below, where it is in contact with the posterior border of the maxilla. The maxilla is long and triangular, deep in the middle, and narrowing both anteriorly and posteriorly. The circum-orbitals consist of probably six small plates which are all quite narrow except

the superior-posterior element, which is extended backward to make contact with the intertemporal. The mandibles are weak and inconspicuous; like the maxillæ, they are toothless. The branchiostegal rays are few and delicate.

The sensory canals of the head are very wide. They run in the bones and open to the exterior by numerous minute pores. The very thin bony covering over the canals is almost invariably broken down in the fossils.

The main canal leaves the body and enters the post-temporal, where it pursues a very sinuous course. It passes upwards and sends off one branch through the tabulars, which forms the "supratemporal commissure." The

Text-figure 13.



Restoration of *Cleithrolepis minor* Broom. $\times 2$.

Drawn from several specimens in the collection of Prof. D. M. S. Watson.

main branch goes forward and passes through the supratemporal and intertemporal into the postorbital, where it turns sharply downward and runs through the posterior and inferior circumorbital ossicles; its further extension could not be traced. A hyomandibular offshoot is given off from the main canal; it is directed ventrally and runs the whole length of the preoperculum close to its posterior margin. There is an independent pair of supraorbital canals in the frontals. They are very wide at their commencement, just in front of the parietals, but as they pass forward between the orbits they become narrower. Their further extension beyond the frontals is lost.

Appendicular Skeleton.

The shoulder-girdle is somewhat reduced. The post-temporal has assumed a thickly rhombic shape and is wedged in between the tabular and the operculum. The supracleithrum is insignificant, but the cleithrum is a rather large triangular-shaped bone; it is almost wholly concealed beneath the operculum. The

exposed portions of the supracleithrum and cleithrum are strongly ridged. Clavicles were not observed in any of our specimens, and, if present, they must be very small.

The pectoral fin consists of about nine rather delicate completely jointed rays. It is only of moderate size.

The pelvic fin is smaller, but otherwise not unlike the pectoral; the rays are very delicate and number about ten.

The dorsal is a triangular fin of moderate size, and is made up of eighteen rays, all of which bifurcate distally and are jointed throughout.

The anal is situated opposite, and is in every way similar to the dorsal, except that in the fin there are only fourteen rays.

The tail is abbreviate-heterocercal, and has a very small scaly lobe extending scarcely a third of the distance to the tip. There are twenty-eight rays in the fin, and these vary a good deal in character. Those medianly situated are very stout and trifurcate distally; the rays immediately above and below these are not so stout and bifurcate distally. Passing from these, the outer rays become still finer and do not bifurcate. The rays are all jointed. The tail is not deeply forked.

Squamation.

The scales are thick, narrow, and very deep. The vertical rows are very distinctly marked off from one another by an anterior thickening of the scales, which produces a series of transverse ridges. It is, however, only with the greatest difficulty that the individual scales in a vertical row can be distinguished. There are thirty-nine complete rows on the body, and in the vicinity of the pelvic there are about sixteen scales in a row. All possess a fine granular ornament.

There is a peculiar broadening and flexing of the scale-rows immediately above the anal and below the dorsal fin. In the triangular patch around the origin of the pectoral fin there is a series of much narrower scale-rows, which run contrary to the general direction of the rows on the body. The lateral-line canal is very wide and open, and is obvious on all specimens.

Systematic Position of Cleithrolepis.

Egerton, when originally describing the genus, was somewhat doubtful as to its affinities; but, being much impressed by its resemblance, in certain respects, to *Platysomus*, he decided to regard it as a member of the Pycnodontidæ, a family with which the Platysomids were then associated. It was removed from this group by Smith Woodward, who, arguing from the reduced nature of the fin-rays and the almost homocercal condition of the tail, included it in the Semionotidæ as a near ally of *Dapedius*. Broom accepted this view, but later Abel placed this genus in the Pholidophoridæ, along with *Hydropessum*.

Now that the structure of the skull is known, it is clear that it is neither a Semionotid nor a Pholidophorid. Its position may, however, still be a little uncertain, for the peculiar structures which it presents may have been derived in different ways. As it stands it is, for all practical purposes, a Perleidid, with a fair degree of resemblance in the structure of the skull and fins to *Meidiichthys*, and it may well have arisen as a deep-bodied modification of such a form.

On the other hand, since the Palæoniscids gave off branches which essentially retain the Palæoniscid head-structure, but become much modified in the fins, it is not unreasonable to suppose that the Platysomidæ may have given

off a similar branch, the structure of which would correspond with that observed in *Cleithrolepis*. The principal arguments in favour of this latter view may be summed up as follows :—

1. In all *Cleithrolepids* (*Cleithrolepis* and *Hydropessum*) the body is extremely deep, and no intermediate forms between these and the normal *Perleidids* are known.

2. The post-temporal has the same peculiar position in both *Cleithrolepis* and the *Platysomids*.

3. The scales, in their ornamentation and articulation, are without exact parallel in either the *Perleididæ* or the *Palæoniscidæ*. They are, however, strikingly similar to the scales of the *Platysomids*, and *Cleithrolepis* is almost indistinguishable in this respect from *Cheirodus*.

4. If the *Platysomids* are a true family there is a distinct possibility of them producing an offshoot, as did the *Palæoniscids*, giving rise in each case to a similar type of structure. The structure of a *Platysomid* would lend itself equally well to the changes involved in the production of the *Perleidid* form.

While the above points may be suggestive, they are in no way conclusive, and it is probable that the ancestry of this genus will remain obscure until new forms or new facts are discovered. The acceptance of the view that *Cleithrolepis* is a *Platysomid* derivative would involve the institution of a new family, and, considering the doubt, it is better at present to regard it as a deep-bodied *Perleidid*.

5. THE NORTH AMERICAN CATOPTERIDS.

In order to proceed to comparisons, it is necessary to know something of the structure of the type-genus of the *Catopteridæ*, *Catopterus*, and of the allied form, *Dictyopyge*. I have examined a large amount of *Catopterus* material, and have been able to redescribe the best-known species, *C. redfieldi*. A concise definition of the genus can also be given.

The structure of the body has long been known in all species of *Catopterus*, but the structure of the head has never been elucidated. This is not surprising, for the heads in all species were short, blunt, and broad, and possessed of a comparatively large cubic capacity, so that when they were squashed in fossilization they usually caved in completely, and the bones were smashed, displaced, and intermingled. The fact that I have been able to attempt the reconstruction of the head of *C. redfieldi* is due to the generosity of the U.S. National Museum, the American Museum of Natural History, and the Cambridge University Museum of Zoology in providing me with a large number of specimens.

In addition to this, it was, fortunately, discovered that the material would stand treatment with a wire brush; and the residue of matrix, which is invariably firmly attached to the highly ornamented outer surfaces of the external bones of the head, became removable. This method of preparation was exercised on a number of specimens of *C. redfieldi*, all of which revealed a certain amount of structure, and which together allowed the reconstruction of most of the skull.

Dictyopyge is much more rare, and I was able to obtain only one specimen of this genus. It was, however, remarkably good, and yielded a fair amount of information, particularly with regard to the head. As the examination of this specimen progressed, it became very doubtful as to whether or not it was identical with the type-species, *D. macrura*, which is the only known North American species of the genus. The type-specimen of *Dictyopyge*

is in the British Museum, and I was able to compare the two forms directly. I finally came to the conclusion that my specimen was specifically distinct from the type, and must therefore become the type of a new species itself.

From these typical North American species the genus has been redefined. It has previously been said to differ from *Catopterus* only in the position of the dorsal fin, but a comparison of the following descriptions will show that there are other important differences in the nature of the squamation, the shape and proportions of the head, etc. It seems likely that certain Old World species hitherto known as *Dictyopyge* ought to be removed from this genus.

Genus CATOPTERUS J. H. Redfield.

Body moderately to deeply fusiform; head short and blunt, terminating in a blunt snout. Gape only moderately wide; suspensorium very slightly oblique. Orbit small and anteriorly placed. Fins of moderate size; dorsal very posteriorly situated, never in advance of the anal; pelvics midway between the anal and pectorals. External bones of the head conspicuously ornamented with ridges and tubercles of ganoiné. Frontals large and elongated; parietals very small and quadrangular, separated by a pair of very tiny dermo-supraoccipitals. Tabular bones in two pairs; outer pair slightly larger than the inner. Supratemporal prominent; intertemporal absent; large pre- and postfrontals form the dorsal border of the orbit. Operculum much smaller than the suboperculum; branchiostegal rays absent; preoperculum narrow behind where it is vertical, but expanded in its upper and slightly-forwardly directed portion; lower margin gently curved. Small X-bone present in front of the operculum. Maxilla massive, deep and plate-like behind, but shallow at its anterior end below the orbit; premaxillæ comparatively large; possessed of a prominent dentition. Mandible moderately robust, deep behind and tapering gradually in front; upper border straight. Teeth numerous and small except on premaxillæ, where they are fewer and larger; all are sharply pointed. Paired fins with few, stout, bifurcating, and distally jointed rays. Rays of the unpaired fins less coarse, distally branched, and completely jointed. Tail hemiheterocercal; scaly lobe very short. Fulcra present on all fins. Scales thick, rhombic, and ganoid; they may have faint surface-striations, and usually display a denticulated posterior border; they do not overlap to any extent on the ventral surface.

CATOPTERUS REDFIELDI Egerton.

The body is rather deeply fusiform. The head is short and very blunt, and slopes rapidly to a pointed snout; it is less than one-sixth of the total length of the body. The gape is moderately wide and the suspensorium slightly oblique. The orbit is rather small and anteriorly placed. The fins are small in relation to the size and depth of the body. The dorsal is very backwardly placed, and its anterior edge is opposite the middle of the anal. The pelvics lie midway between the anal and the pectorals. The dimensions of 631 G. (Am. Mus. Nat. Hist.), a typical specimen, are:—

| | |
|----------------------|---------|
| Total length | 162 mm. |
| Greatest depth | 50 „ |
| Length of head..... | 25 „ |

Head.

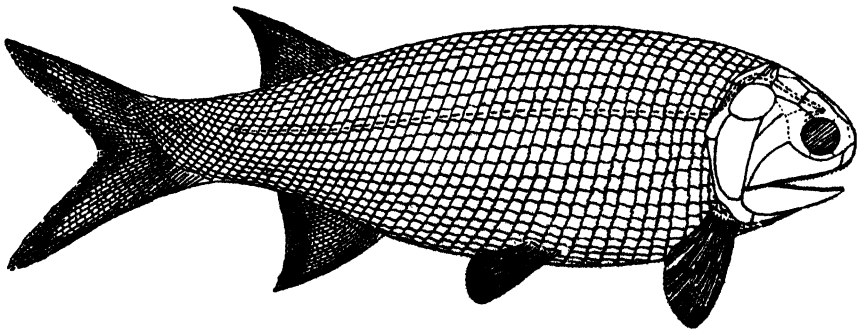
The external bones of the skull are all covered by a shining layer of ganoiné which is very heavily sculptured into a series of ridges and tubercles. The

anterior portion of the cranial roof is formed by a pair of large elongated frontals. The lateral margin of each consists of two gentle concavities, the posterior one in contact with the supratemporal and the anterior one meeting the whole of the upper border of the postfrontal and the posterior part of the upper border of the prefrontal. In the snout region a median "ethmoid" is partly wedged between the frontal bones. Between this median element and the prefrontals, and in contact with the extreme anterior border of the frontals, there is a pair of nasals.

The cranial roof behind the frontals is much less uniform, and is made up of a large number of small elements. There is a row of four quadrangular-shaped bones adjoining the posterior margin of the frontals. They constitute a peculiar little series of which the homologies are not particularly obvious; but it seems clear that the outside pair are true parietals, for the terminations of the supraorbital sensory canals come up to them, and end on their anterior border, as they do on the parietals of all allied forms.

The smaller pair of bones internal to these are best regarded as dermo-supraoccipitals which have become reduced in size and have inserted them-

Text-figure 14.



Restoration of *Catopterus redfieldi* Egerton. $\times \frac{1}{4}$.

Drawn from 631 a, and other specimens in the collection of the American Museum of Natural History, New York.

selves between the parietals, so separating these elements. That this view is not unreasonable is indicated by a comparison with the South African genus *Helichthys*, which is closely allied to *Catopterus*. In the former genus the parietals are small and triangular, and their apices just meet in the middle line; behind them there is a large pair of dermo-supraoccipitals. It would appear that in *Catopterus* these small triangular parietals have had their apices truncated and have become still smaller, quadrangular, and entirely separated. The dermo-supraoccipitals have taken their place in the middle line immediately behind the frontals, and have, incidentally, become much reduced. This separated condition of the parietals is exceedingly rare among the older bony fishes. It occurs in Pycnodonts, and is, of course, the rule in Teleosts.

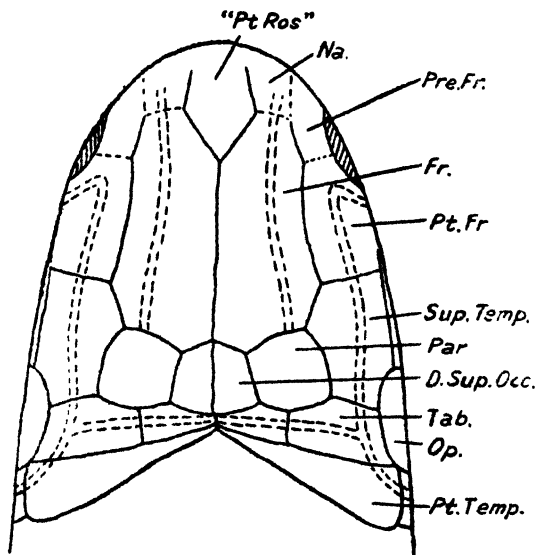
The tabular row consists of two pairs of small bones which are packed in behind the parietals and dermo-supraoccipitals, and in front of the long, narrow, post-temporal. The outer pair of tabular bones are larger, and come into contact with the supratemporal and the top of the operculum.

The supratemporal is a large element about twice as long as broad, with a sinuous upper border which adjoins the outer edges of the parietal and the

posterior part of the frontal. Below it is attached to the operculum and the bones in front of it. The anterior border of the supratemporal is perfectly straight, and meets the posterior margin of the postfrontal. The latter bone continues forward in contact with the frontal until it reaches the orbit, where it meets a prefrontal, and together they form the dorsal part of the orbital margin.

The operculum is small and is somewhat rounded. It meets the outer tabular and the posterior part of the supratemporal above, and is followed below by a suboperculum which is at least twice as large as the operculum and is of a rather quadrangular shape. It extends down to the articulation of the mandible, where its lower border is rounded. The remains of branchiostegal

Text-figure 15.



Catopterus redfieldi Egerton. Restoration of the head, dorsal aspect. $\times 2\frac{1}{2}$.

Drawn from 2431, 631 G. and other specimens in the collection of the American Museum of Natural History, New York.

Dermo.Sup.Occ. = Dermo-supraoccipital. *Fr.* = Frontal. *Na.* = Nasal. *Op.* = Operculum. *Par.* = Parietal. *Pt.Fr.* = Postfrontal. *Pt.Ros.* = Postrostral. *Pt.Temp.* = Post-temporal. *Pre.Fr.* = Prefrontal. *Sup.Temp.* = Supratemporal. *Tab.* = Tabular.

apparatus are not visible in any of the specimens examined, and the space between the mandibles appears to be protected by a widening out of the anterior extension of the cleithrum and of the clavicles. There may be a small median plate just behind the symphysis of the lower jaw.

The preoperculum is not distinctly in two shanks, but there is a narrow, vertical, posterior area and a wider antero-dorsal one. There is no angular bend in the lower margin, as in the Palæonsioids and certain other *Catopterids*. Between the operculum and the preoperculum there is a small element corresponding to Traquair's bone X.

The bones of the snout and those behind the orbit could not be satisfactorily

made out in any of our specimens, and the placing of the sutures is problematical. In view of this uncertainty, it is not proposed to discuss them here, but their suggested outlines are dotted in on the restoration of the head.

The maxilla is large and prominent; deep and plate-like behind, and shallow-ing somewhat below the orbit. The mandible is similarly deep behind, and tapers uniformly to the anterior end. The premaxillæ are stout little bones, and are conspicuous in most of our specimens; they have a few prominent sharply-pointed conical teeth firmly fused on to them. The maxillæ and mandibles also have a series of pointed conical teeth, but these are very numerous, and are considerably smaller than those on the premaxillæ.

Sensory Canals of the Head.

The sensory canal system cannot be fully made out, but, so far as can be seen, it is exactly similar to that of normal Palæoniscids and of *Helichthys*.

The main canal comes up from the body, passes through the supracleithrum into the outer tabular, where it sends off a branch at right angles which meets a similar branch from the other side and forms the "supratemporal commissure." It then passes through the supratemporal to the postfrontal, where it turns sharply downward and passes below as the infraorbital canal. The supra-orbital canal arises at the hinder end of the frontals, and is there in contact with the parietals. It traverses the frontals and passes into the nasals, but its further extension beyond these bones could not be traced. Little is seen of the hyomandibular branch, for the cheek-region is invariably in a bad state of preservation. Its course in the mandible can, however, be seen in one specimen. The pit-organs could not be distinguished.

Appendicular Skeleton.

The membrane-bones of the shoulder-girdle are massive and highly ornamented. The supracleithrum is a large and prominent bone, and is preserved in all species; it is quadrangular, and about twice as deep as broad. The cleithrum is also large, and consists of two shanks of about equal size, one horizontal and the other vertical. The vertical shank narrows to a point dorsally, where it is in contact with the supracleithrum; the anterior edge is straight and thickened, but the posterior part is thinner and widens below. The horizontal shank goes forward inside the mandible, and extends a fair distance toward the symphysis. The external surface is very convex. These forward extensions of the cleithra are overlapped anteriorly by large triangular clavicles. As was suggested above, the extensive development of these bones between the lower jaws probably compensates for the absence of branchiostegal rays.

The pectoral fin has a much restricted base, and consists of few, about six, rays which branch immediately after their origin. Each ray has at least four branches, and they are all fused for a long distance proximally, but are articulated toward the tips. There is an anterior fringe of numerous large fulcra.

The pelvic fin is exactly similar in construction, and is also characterized by a much restricted base. It is smaller, and has about seven rays.

The rays of the dorsal fin are rather coarse, and are distally branched. They number twenty-one, and all are closely articulated throughout. There is a fine fringe of fulcral scales extending along the whole of the anterior edge.

The anal is in a precisely similar condition as the dorsal, but it consists of twenty-five rays.

The tail is hemiheterocercal, with the scaly lobe much reduced. The lobe is distinct but very short, and does not stretch one-quarter of the distance toward the tip. There are forty-two rays, all fairly coarse, but those on the dorsal and ventral edges are rather finer than those which are medianly placed. All are distinctly and extensively branched, the branching starting about half-way along the rays: all are closely articulated except a few of the more ventral rays, which have a very short proximal portion without articulations. A fine and very numerous set of fulcra fringe both the dorsal and ventral edges of the tail.

Squamation.

The body has an armouring of thick, rhombic, and brilliantly-shining ganoid scales. On the flank they are about as deep as broad, and on a form of normal length (160 mm. approx.) measure 2.5 mm. across. The posterior borders are deeply denticulated, and there are generally five small denticles, the most ventral of which is much the largest, and is prolonged on to the surface of the scale as a very faint ridge which dwindles away anteriorly.

On some of the scales all the denticles are prolonged forward as slight ridges for a short distance. This characteristic reaches its maximum on the more dorsally-placed scales immediately behind the head, and the surfaces of these are distinctly ridged. The scales show no decrease in depth dorsally, and even on the ventral surface show very little.

There are twenty-six scales in a vertical row between the pectoral and anal fins, and forty vertical rows on the body, counting up to the beginning of the ventral lobe of the tail. There is a total of fifty-two vertical rows on the whole body if the scaly lobe of the tail is included.

Genus *DICTYOPYGE* Egerton.

Body fusiform; head moderate to rather large in size. Gape moderate; suspensorium practically straight. Fins moderate in size except for the anal, which tends to be rather large and rounded in outline; dorsal slightly in advance of the anal; pelvics midway between the anal and the pectorals. Scaly lobe of the tail very small, giving the fin an almost homocercal appearance. External bones of the skull finely sculptured; frontals elongated; parietals very small; tabulars more prominent, probably in two pairs. Supratemporal large; extending from the tabulars forward to the postfrontal; intertemporal absent. Postfrontal large, adjoining the supratemporal and extending forward to form the postero-dorsal part of the orbital border. Operculum small, much wider than deep; suboperculum very much larger than the operculum and considerably deeper than wide; it tends to be semicircular in shape. Preoperculum expanded above, but very narrow below behind the maxilla. Maxilla deep behind, but very slender anteriorly below the orbit. Fin-rays distally bifurcated; those of the dorsal and anal fins completely jointed, and more numerous than the endoskeletal supports. Tail hemiheterocercal, with numerous bifurcated and completely jointed rays. Fulcra present on all fins. Scales fairly thick, rhombic, and ganoid; surfaces smooth. Ridge-scales present on the dorsal and ventral aspects of the tail-pedicle; body-scales overlapping extensively on the ventral surface.

DICTYOPYGE DECIPIENS, sp. n.

The following description is based upon one specimen (654 g), which is in the collection of the American Museum of Natural History, New York.

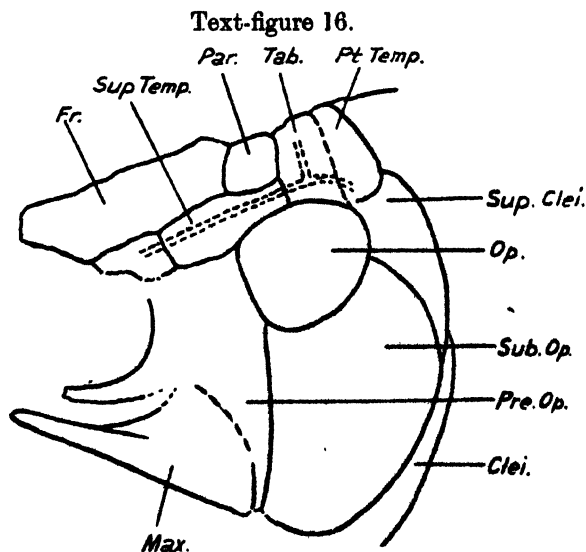
It represents a fusiform fish with a large head, which occupies about one-fourth of the total length. The length of the head gives a moderately wide gape, but the suspensorium is practically straight. Except for the anal, the fins are not particularly large. The dorsal is well in advance of the anal, the anterior edge of the latter being opposite the posterior third of the dorsal fin.

Dimensions :—

| | |
|--------------------------------|---------|
| Total length | 120 mm. |
| Greatest depth (approx.) | 33 „ |
| Length of head..... | 27 „ |

Head.

The head is incomplete, but sufficient can be discerned to indicate that the structure was generally similar to that of *Catopterus*. The external bones are very extensively ornamented with ridges and tubercles. Ridges are present on the cheek, but tuberculation is the more common form of ornament, and is present exclusively on the bones of the cranial roof and on the operculum and suboperculum.



Dictyopyge decipiens, sp. n. Outline drawing of the head. $\times 2$.

From the type-specimen, 654 G, in the collection of the American Museum of Natural History, New York.

Clei. = Cleithrum. *Fr.* = Frontal. *Max.* = Maxilla. *Op.* = Operculum. *Par.* = Parietal. *Pt.Fr.* = Postfrontal. *Pt.Temp.* = Post-temporal. *Pre.Fr.* = Prefrontal. *Pre.Op.* = Preoperculum. *Sub.Op.* = Suboperculum. *Sup.Temp.* = Supratemporal. *Sup.Clei.* = Supracleithrum. *Tab.* = Tabular.

The frontal is long and narrow; it is in contact laterally with a supra-temporal, post- and prefrontal, and anteriorly it adjoins a median "ethmoid." There is a small parietal behind it, but, owing to the broken nature of the specimen, it is impossible to say whether or not the tiny dermo-supra-occipitals of *Catopterus* are represented here. From the relative positions of the bones preserved it is possible that they may be absent.

Posterior to the parietal the tabular can be seen very clearly carrying the main-line sensory canal and its tabular branch. This bone appears to be overlapping another one toward the middle line, and it is likely that there is a second, and smaller, pair of tabulars internal to the larger outer ones.

The supratemporal is rather large, and is very similar to the homologous bone in *Catopterus* and *Helichthys*; it is of similar shape, and has precisely the same relationships. Dorsally it abuts against the lateral border of the parietal and the posterior part of the lateral border of the frontal. It meets the outer tabular posteriorly, and receives the main canal of the sensory system from it. It adjoins the postfrontal anteriorly with a straight and even suture, and below it is in contact with the operculum and the bones in front of it.

The operculum is wider than deep and is roughly quadrangular, with the corners rounded. The suboperculum is about twice the size of the operculum, and is much deeper than wide. The preoperculum is expanded above and narrow below; it is not in two shanks, and the lower border is in the form of a sweeping curve. The maxilla is wide behind where it is in contact with the preoperculum, but narrows rapidly and considerably in front below the orbit. The mandibles and the bones of the snout are not preserved in this specimen.

Appendicular Skeleton.

The pectoral girdle is poorly preserved, and the pectoral and pelvic fins are lacking. The membrane-bones of the shoulder-girdle are ornamented. The post-temporal is a long, narrow bone, wider laterally, and narrowing as it extends in toward the mid-dorsal line. The supracleithrum and cleithrum are apparent, but are too imperfect for description.

The dorsal fin, which is triangular and of moderate size, is made up of sixteen rays, all fairly coarse, but the anterior ones particularly so. They are extensively branched, and articulated throughout. There is an anterior fringe of fine fulcra.

The anal fin has a very characteristic appearance. It is very much extended, commencing opposite the posterior part of the dorsal and reaching back on to the tail-pedicle almost up to the ventral lobe of the tail. The rays number twenty-seven and are quite coarse, but that they outnumber the endoskeletal supports is clearly shown in this specimen, for the endoskeletal elements of the anal fin are well preserved. The rays are branched and very closely articulated. There is an anterior fringe of fine and small, but very numerous fulcra.

The tail is hemiheterocercal, but the scaly lobe is very slightly produced and is quite inconspicuous, so that, superficially, the tail may appear to be homocercal. The finer rays are to be found dorsally and ventrally, those medianly placed are rather more coarse. There are fifty-five rays; all are branched, and are completely and closely articulated. Large ridge-scales are present at the base of the dorsal lobe, and these are replaced distally by numerous very fine fulcra. Fulcra are probably also present on the edge of the ventral lobe, but the slightly damaged nature of this part of the tail makes this uncertain.

Squamation.

The scales are numerous, moderately thick and ganoine-covered. They are deeper than broad on the anterior flank, and these measure 2.5×1.5 mm. There is no appreciable decrease in depth dorsally, but on the ventral surface they become exceedingly shallow and are very numerous. The surface of the scales is quite smooth and unornamented, and the margins are entire. There

are about twenty-seven scales in a vertical row just in front of the dorsal and anal fins and thirty-eight vertical rows on the body, counting to the beginning of the ventral lobe of the tail.

Observations.

The specimen described above was accepted at first as *D. macrura*, but a comparison between it and the type-specimen of *D. macrura* clearly revealed the specific distinctness of the two. The essential points of this comparison are given below. The type of *D. macrura* is only 18 mm. longer than the other; so that the differences in proportion are probably genuine, and not due to growth-changes.

D. decipiens is more deeply fusiform than *D. macrura*; in the latter the body, measured from the back of the operculum to the end of the scaly lobe of the tail, is 100 mm. long, but the depth is only 30 mm. The corresponding measurements in *D. decipiens* are 77 mm. and 33 mm. This difference is more obvious posteriorly, and the depth of the body at the anterior end of the anal fin is 22 mm. in *D. macrura* and 27 mm. in *D. decipiens*. The head is comparatively larger in *D. decipiens* where it is contained about four times in the total length. In *D. macrura* the head is of moderate size, and is contained approximately five times in the total length.

In *D. macrura* the anterior edge of the dorsal is barely in advance of the anal, but in *D. decipiens* the greater part of the dorsal fin is in front of the anterior edge of the anal. The anal fin is thus moved backwards, and it is found that there are only three enlarged ridge-scales between its posterior border and the ventral lobe of the tail: whereas in *D. macrura* the anal is further forward, and there are five ridge-scales between it and the tail. The tail of *D. decipiens* has a more bushy appearance, and contains more rays than that of *D. macrura*. Newberry states that there are thirty-five to forty rays in the tail of the latter species, and the British Museum specimen has forty-two. *D. decipiens* has fifty-five, and this difference, like the others set out above, is too great to be explained as individual variation, and is of specific value.

6. DERIVATIVES OF THE PALÆONISCIDÆ.

Stensiö, in his account of the Triassic fishes of Spitzbergen, brought together the Catopteridæ (then comprised of *Catopterus*, *Dictyopyge*, and *Perleidus*), and the family which he himself had raised, the Colobodontidæ; and showed conclusively that the members of the latter group could not by any means be placed nearer to the Semionotids than to the Palæoniscids, as had been done by Stolley. Hence he grouped together *Catopterus*, *Dictyopyge*, *Perleidus*, *Colobodus*, *Dollopterus*, and, doubtfully, *Meridenosia* in the Catopteridæ. This was a good view at the time, and did emphasize the important fact that all these fishes, although they may show a good deal of variation in many respects, had retained the essential characteristics of the Palæoniscid head, and in this differed profoundly from the Semionotidæ and all the higher Ganoids.

In the present paper new genera have been added to this group, and some new facts regarding certain of the older genera have been put forward. When these are considered as a whole it becomes apparent that the variation in structure in the group is fairly considerable; and of more moment is the fact that this variation is not continuous, but there is a decided break, one group of genera showing one type of structure, another group a quite distinct and easily recognizable grade, between which there are no known intermediates.

Both of these groups appear simultaneously at the beginning of the Triassic, and exist side by side until the close of that period.

The remarkable uniformity which the groups display within themselves makes it desirable to place the forms into two families—the Catopteridæ and the Perleididæ. In this way the significant differences between them will be noted and appreciated.

They probably represent two distinct offshoots from the Palæoniscidæ, which show a little parallel development in the reduction of the elements of the fins. That this is not unlikely is clearly demonstrated by close parallel development of the fins in the quite unrelated Perleididæ and Semionotidæ. The Perleididæ are more advanced in fin-structure than the Catopteridæ, and one may be tempted to suppose that they arose from the Catopterids, perhaps at a very early stage. A consideration of the structure of the head throws very great doubt on this view, and suggests that the two groups were independent from the outset.

The fact that the Perleididæ are separated from the Catopteridæ does not necessarily indicate that the former group must take a higher place in the classification. The two families have very close affinities, and both must be kept near to the Palæoniscidæ; the Perleididæ just as much so as the Catopteridæ. It is necessary clearly to differentiate them from the Semionotidæ and their allies, for these represent a far different, more successful, probably earlier, and certainly quite independent Palæoniscid offshoot.

There appears to have been a complete break up of the Palæoniscid fishes toward the end of the Permian, when several new lines, showing a greater or less degree of modification of structure, arose from this ancient group. Two of these offshoots, the Catopteridæ and Perleididæ, retained their archaic heads, had a brief existence, and eventually came to nothing. Another offshoot, the Semionotidæ, had a much modified and much more satisfactory jaw apparatus, and gave rise to the higher Ganoids, and eventually to the Teleosts.

Other Palæoniscid offshoots of varying sorts had varying fates. The Saurichthyidæ adopted a peculiar type of structure, and existed in their characteristic form until the Upper Liassic, when they became extinct. The Sturgeons also arose from the Palæoniscids, probably about this time, and have managed to survive, in a restricted habitat, up to the present day. It is likely that further research on the fishes of this period will reveal the presence of other Palæoniscid derivatives, the existence of which can only be guessed at at present.

In a later section a full account of, and a comparison between, the structures of the Catopteridæ and Perleididæ will be given, the constant differences between the two groups will become apparent, and the necessity for instituting a second family will be understood.

In naming the second family it was intended to revive the term Colobodontidæ; but on further reflection this was deemed unwise, for the name has had a brief but somewhat chequered history, and appears to have a different significance to different authors. A more immediate reason for its rejection lies in the fact that the genus *Colobodus* must be a member of the Colobodontidæ, and at the moment it is very doubtful as to where *Colobodus* really belongs. The name was given by Agassiz to a fragment of dentition from the Muschelkalk. There is no reason for supposing that this belonged to a fish which had an archaic head with Palæoniscid affinities such as is possessed by the species in the so-called *Colobodus*, s. str., of Stensiö (Andersson, 1916). It might well have belonged to the Semionotid fish later called *Paralepidotus* by Stolley.

The uncertainty about the type-specimen makes it very undesirable to

use this as a family name, and as an alternative the term *Perleididæ* may well be adopted, for the researches of Stensiö have left us with a very full knowledge of the genus here named.

The subdivision of the forms previously considered as *Catopterids* into the two families now recognized is given below. Genera newly introduced are marked by an asterisk.

CATOPTERIDÆ.

Catopterus.

Dictyopyge.

Helichthys *.

Dædalichthys *.

PERLEIDIDÆ.

Perleidus.

Colobodus (s. str. of Stensiö).

Dallopterus.

Meridensia.

Meidiichthys *.

Cleithrolepis *.

Hydropessum *.

7. A DISCUSSION ON, AND A COMPARISON OF, THE STRUCTURE AND ORGANIZATION OF THE FAMILIES CATOPTERIDÆ AND PERLEIDIDÆ.

The known members of these families are usually small. Certain species have an average length of only 70 mm., but *Perleidus woodwardi* attains a length of 300 mm., and certain species of *Colobodus* exceed this. The length in the majority of species ranges between 100 and 150 mm. It is a notable fact that all the larger forms were marine.

The shape of the body is usually normally fusiform, invariably so in the *Catopteridæ*; but tendencies toward depth of body are shown in certain members of the *Perleididæ*, particularly in *Perleidus woodwardi* and *Colobodus*. This tendency culminates in the production of the exceedingly deep-bodied and laterally-flattened forms *Cleithrolepis* and *Hydropessum*, which are nearly as deep as long.

There is one dorsal fin, which is invariably well within the posterior half of the body. Its position with regard to the anal is variable, and is of taxonomic importance. It may be in front of, opposite, or behind this fin. It is only behind the anal in one genus, *Catopterus*. The pelvic fins are abdominal.

The head is usually of medium size, but in certain members of both families, as *Catopterus*, *Cleithrolepis*, and *Hydropessum*, it is quite small. In the more normal forms the length of the head approximately equals the depth of the body.

Head.

Nothing is known of the structure of the neural cranium. The membrane-bones of the head are usually ornamented, invariably so in the *Catopteridæ*, and commonly in the *Perleididæ*. In certain *Perleidids*, however, the ornament is lost, and the bones of the skull are thin and smooth. This condition is reached in *Meidiichthys*. The skull-bones, when ornamented, possess a covering of ganoine, and the ornament, which is formed by the sculpturing of this layer, consists of either a series of ridges and furrows or a series of tubercles. Both types are commonly present on the same head, and not infrequently on the same bone. In some bones the ridges and furrows radiate from centres of ossification, but in others they run more or less longitudinally with the length of the bone. The ornament is most persistent ventrally, and in some forms it may be feeble or absent on the skull-roof, while it is quite strongly developed on the maxillæ and the mandibles. This condition is displayed in *Helichthys elegans*, in which the frontals have attained an almost perfect smoothness.

The Cranial Roof.

The frontal bones are invariably large, and are always the principal roofing elements in the skull. They find their greatest development in the Perleididæ, particularly in *Meiodictys* and *Cleithrolepis*. Behind the large frontals there is much variety of structure, the size and position of the parietals differs very greatly in different forms. A dermo-supraoccipital bone may be present in the Catopteridæ, and there may be one or two pairs of bones in the tabular row.

It is in the Catopteridæ that the parietals are small and very variable; in the Perleididæ, although the size varies to some extent, the shape is more constant. In the latter family they are square or rectangular, usually square, and their outer borders form a straight and continuous line with the outer borders of the frontals. The square shape of the parietals and the perfectly symmetrical way in which they fit behind the frontals is very constant in this family, and is almost identical with the condition of these bones in *Amia* and the higher Ganoids generally. A further point of resemblance is that the sutures between parietals and between the frontals, that is, the median suture of the head, is irregular and interlocking in the Perleidids, as in *Amia*. The Catopterids, on the other hand, usually have a perfectly straight median suture.

Colobodius bassanii is the only member of the Perleididæ to make any notable departure from the established pattern of the frontal and parietal bones. In this form the parietals are rather elongated, and the outer border of the frontals and parietals is not straight, but pursues a very sinuous course.

In the Catopteridæ the parietals are more variable; in the lower Triassic form *Helictys* they are rather small and triangular-shaped, and their apices just meet in the middle line. In the Upper Triassic *Catopterus* they have undergone reduction, and are still smaller; their apices have been truncated, and they are not now triangular, but irregularly quadrangular, and they do not make contact in the median line. Between them is wedged a tiny pair of dermo-supraoccipitals.

These latter bones are present as distinct elements in the Catopteridæ, but not in the Perleididæ. In *Helictys* they are a very prominent pair of bones, triangular in shape and larger than the parietals, with the bases meeting in the middle line and the apices directed outwards. They lie immediately behind the triangular parietals, and a fusion of these elements would give a fair-sized square plate, comparable in shape and size to the parietals of *Meiodictys* and *Perleidus*. Indeed, it is possible that the "parietal" in the Perleididæ represents a fusion of the parietals and dermo-supraoccipitals, for when these bones are separate in *Helictys* the parietals bear the median line of pit-organs, and the dermo-supraoccipital the posterior line of pit-organs. In *Perleidus* these two lines of pit-organs bear precisely the same relation to one another in size, shape, and spacing, but both are borne by the large square parietal, and seem to afford evidence of the multiple nature of this bone. Little is known of the condition of the pit-organs in Palæoniscids, but in *Coccocephalus* the triangular-shaped parietal is marked as bearing only one line of pit-organs presumably the median line (Watson, 1925). Stensiö observed a similar median line in the parietals of the Palæoniscid *Boreosomus* (Stensiö, 1921).

The tabular row is usually narrow, and is frequently made up of a single pair of bones. These are invariably penetrated by the "supratemporal commissure" of the main lateral line canal. In *Catopterus* there are two pairs of tabulars, but this condition is uncommon. In *Helictys* there is an unusually large pair of tabular bones which have a triangular appearance, but which are

in reality rather square, their anterior portion being overlapped by the bones in front.

The structure of the head anterior to the frontals cannot be so satisfactorily dealt with, for this region is always badly preserved and is difficult to interpret. The structure is only fully known in two forms, *Perleidus* and *Meidiichthys*, but a good deal has been made out in many of the others.

All forms possess a rather large median plate anterior to the frontals, which has usually been termed the ethmoid. It has been called a nasalo-postrostral in *Perleidus* by Stensiö (1921), and in *Meidiichthys* a rostralo-postrostral. In this paper it is preferred to regard the antorbitals of Stensiö as nasals, and then the median plate can only be made up of rostral and postrostral elements. There is certainly no independent median rostral in either *Perleidus* or *Meidiichthys*, although the lateral rostral may remain distinct.

In all forms the rostralo-postrostral is flanked by a pair of nasals, and these bones always take the continuation of the supraorbital canal from the frontals. In the Catopteridæ, as in *Helichthys* and *Catopterus*, the nasal adjoins a prefrontal at its outer margin; but in the Perleididæ (*Perleidus* and *Meidiichthys*) the outer margin of the nasal is free, and forms part of the border of the orbit. In the latter genera the snout is completed by a pair of premaxillæ ventrally and a pair of rostrals laterally.

Between the roof and the opercular apparatus on the cheek there is a row of bones which carry the main line of the sensory canal from the body up to the orbit. These are very different in the two families, but inside each family a fair degree of uniformity is attained. In the Catopteridæ this area is essentially occupied by only one bone, the supratemporal, which extends from the tabular behind to the post-frontal in front. It is frequently longer than broad, although the proportions vary with the shape of the head in different species.

In the Perleididæ there are generally two bones in this situation, a supra-temporal and an intertemporal, as in *Meidiichthys* and *Cleithrolepis*, but in *Perleidus* the two appear to have fused (Stensiö, 1921).

The circumorbital bones show an entirely different arrangement in the two families, and must be considered separately.

CATOPTERIDÆ.

It is unfortunate that the orbital margin could not be completely made out in any of the forms in this group. Even the numerous well-preserved heads of *Helichthys* break down at this point, and while the dorsal ventral and posterior borders can be reconstructed, the anterior portion is imperfect in all forms.

Two large bones come into the orbit dorsally, and are divided by a vertical suture. They have been called the pre- and postfrontals, but the postfrontal may be a compound bone, which includes the intertemporal. This conclusion is possible, firstly, because there is not an independent intertemporal in these forms, and, secondly, on the evidence of the sensory canals. In the Palæoniscid heads described by Watson (1925, 1928), the right-angle bend in the main sensory canal, where it has passed forward to the orbital margin and then bends down sharply and becomes the infraorbital canal, is always in the intertemporal. The full width of this bone is in contact with the supratemporal, and the postfrontal does not usually adjoin the supratemporal at all. This element has, therefore, the relations of an intertemporal in its situation with regard to the supratemporal and in the nature of the sensory canal it carries; but it is a large bone, and anteriorly has the relations of a postfrontal in its position with regard to the frontal, and in that it forms the border of the orbit.

It might therefore be properly called an intertemporo-postfrontal, but such nomenclature is best avoided, for it commits one to a system which becomes increasingly difficult to carry out, and from which conclusions are derived that are so theoretical that they may be embarrassing. It is preferred to use the term postfrontal in this connection, for although a fair case can be made out to support the view that this large bone represents a fusion of two elements, it is equally possible, and in some vertebrates more likely, that the reduction in the number of osseous elements in the skull has been accomplished by a process of atrophy and hypertrophy; some elements totally disappearing and others expanding to take their place. Views with regard to fusions of elements in fossil forms are difficult or impossible to substantiate, considering the rarity of intermediate forms and the complete lack of embryological evidence.

Below the postfrontal there is a fair-sized postorbital which is of variable shape, but is always angular. Its lower border usually coincides with the preopercular maxillary suture. The maxilla is surmounted by an uncertain number of ossicles, but they are so firmly united to this bone that their boundaries are difficult to discern.

PERLEIDIDÆ.

The complete circumorbital ring has been satisfactorily reconstructed in a number of forms in this group. The postfrontal is usually the largest element, and occupies a postero-dorsal position abutting against the intertemporal. There is a postorbital below which in *Meiodictys*, and to some extent in *Colobodius* and *Dollopterus* (Stolley, 1920), is peculiar in having its upper border gently rounded. Anterior to this, and forming the ventral border of the orbit, there is a long, narrow, jugal, and in *Meiodictys* a small, lachrymal. On the superior border of the orbit there is a prefrontal adjoining the anterior part of the outer border of the frontal. Between the prefrontal and the postfrontal there are a variable number of supraorbital ossicles—two in *Meiodictys*, one in *Perleidus woodwardi*, and a minimum of two in *Perleidus altolepis*. In *Perleidus* and *Meiodictys* the circumorbital ring is completed anteriorly by the coming in of the nasal to fill the gap between the prefrontal and the lachrymal or jugal below.

The Membrane-bones of the Cheek and Jaws.

The most obvious and most significant feature in the structure of the head in both families is the way in which the cheek-region is covered essentially by the maxilla and preoperculum, in this respect showing complete agreement with the Palæoniscids, and a sharp contrast with all later groups. While there is not a single exception to this rule, there is a minor variation in the relative sizes of the maxilla and preoperculum. In the more primitive Catopterygids, as in *Helicthys*, the maxilla tends to be very deep, plate-like, and quadrangular behind. Consequently, the lower border of the preoperculum has a right-angle bend, and the latter bone appears to be made up of two shanks, a narrow posterior vertical one and a wider horizontal one. This is also the common condition in the Palæoniscidæ.

Correlated with the straightening of the suspensorium and the restriction of the gape in higher forms, the plate-like quadrangular nature of the posterior part of the maxilla is lost. This bone becomes rather triangular, with the greatest height in the middle, and the posterior border is not angular, but gently curved. Such is the condition in all the members of the Perleididæ, and also

in *Dictopyge*; it is particularly well displayed in *Cleithrolepis* and *Meidiichthys*. The maxilla and preoperculum together form the cheek-covering, as in the Palæoniscidæ. Any loss in size in one is gained by the other; hence the loss of the dorso-posterior angle of the maxilla in the higher forms accounts for the preoperculum being relatively larger in these than in the more primitive Catopterids.

Although the maxilla is extremely Palæoniscid in almost every way, it shows one minor but interesting difference. The maxilla in Palæoniscids always exhibits a downward sweep at its posterior end, and overlaps the mandible. There is little trace of this in the Catopteridæ and Perleididæ, the lower border of the maxilla being almost straight in both groups.

The direction of the suspensorium is very variable. In the Catopteridæ it is usually oblique and backwardly directed, as in the Palæoniscids, but in one form, *Dictopyge*, it is quite straight. In the Perleididæ it is generally vertical, but it may be slightly inclined either backward or forward. It is vertical in *Colobodus* and *Dollopterus*, slightly backwardly inclined in *Perleidus*, and very slightly forwardly inclined in *Meidiichthys* and *Cleithrolepis*. The gape, therefore, tends to be less wide in the Perleididæ; but although a swinging forward of the suspensorium is usually accompanied by a restriction of the gape, this is not necessarily so; a slight elongation of the snout can compensate for the length lost posteriorly. It is found in some of these forms that, while the suspensorium may be vertical or even forwardly directed, the gape is not really small.

The operculum is generally much smaller than the suboperculum, and only in *Colobodus* is the reverse sometimes true. In certain of the Catopteridæ, in correlation with the oblique suspensorium, the operculum tends to take up a similar position to that which it attains in the Palæoniscidæ—above and in front of the suboperculum. In the Perleididæ it is directly above the suboperculum, and never in front of it. This arrangement is also shown by the later Catopterids. There is a variable number of small bones (X) between the operculum and the preoperculum which belong to the opercular series. Their position, posterior to the hyomandibular sensory canal, excludes them from the preopercular bones. In the Catopteridæ there are usually one or two small bones between the anterior margin of the preoperculum and the post-orbital and postfrontal. Both of these groups of elements occur frequently in the Palæoniscidæ.

There is no interoperculum in either family. In the Perleididæ there is a normal set of branchiostegal rays below the suboperculum. In the Catopteridæ the position is extraordinary, for branchiostegal rays appear to be absent. This is certainly the case in *Helichthys*, where many beautifully-preserved heads show never a trace of branchiostegal rays, and is also apparently true of *Catopterus* and *Dædalichthys*. In *Helichthys* the opercular series is completed by a third plate which lies below the suboperculum. One may be tempted to call this an interoperculum, but its position does not correspond to that held by the element of that name in other fishes. Although it is larger, it is occupying precisely the same position as that held normally by the first branchiostegal, and is best called the modified first branchiostegal ray. In this genus the rest of the series is lost.

It has been impossible to distinguish the individual elements in the mandible. It is often stout and deep, particularly in the Catopteridæ, and is a little weaker in the Perleididæ. Its minimum development is seen in *Cleithrolepis*, where it is feeble and shelf-like.

The dentition in the Catopteridæ is quite uniform, and agrees with most

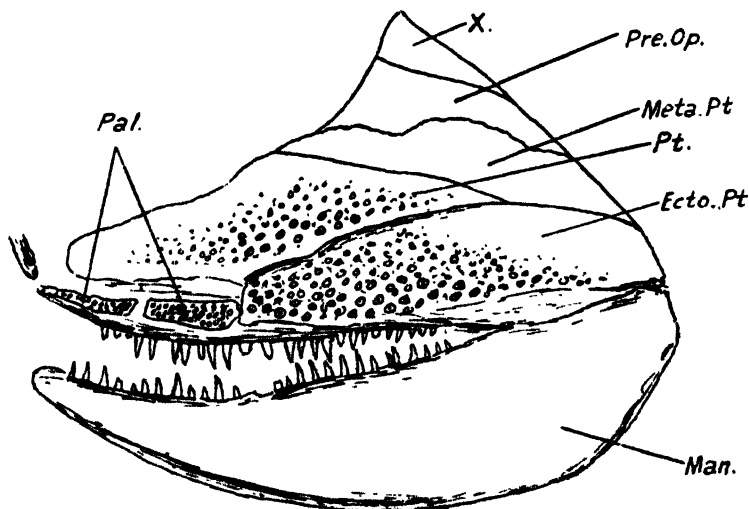
Palæoniscoids in having a large series of small, sharply-pointed, conical teeth. With this dentition and their wide gape they were, no doubt, typically predaceous fishes.

More variety is shown in the Perleididæ, where there is a tendency for the teeth to be long and cylindrical, with rounded ends, a condition usual in *Meidiichthys* and *Perleidus*. In *Perleidus woodwardi* some of these become reduced and are small and blunt, appearing to be crushing-teeth. In *Colobodus*, s. str., the teeth are long and pointed, or long and cylindrical. Many scraps of dentition of a very blunt and crushing nature are assigned to *Colobodus*, but it is extremely unlikely that these belonged to Perleidid fish at all, and more probably belonged to a genus nearly allied to *Lepidotus*. The teeth of *Dollopterus* resemble those of *Meidiichthys*. In *Cleithrolepis* the jaws are smooth and teeth are entirely lacking; in this respect it is at present unique in the family.

Palate.

In the large series of specimens which have been examined, only one (P. 7 B in Prof. Watson's coll.) shows the palate in an understandable condition. This specimen represents the anterior half of a fish with the skull peculiarly squashed. It certainly belongs to the Catopterid genus *Helichthys*, and is probably *H. obesus*.

Text-figure 17.



Palate and associated bones of *Helichthys*. $\times 6$.

Drawn from the specimen P. 7 B in Prof. Watson's collection.

Ecto.Pt. = Ectopterygoid. *Man.* = Mandible. *Meta.Pt.* = Metapterygoid. *Pal.* = Palatines.
Pre.Op. = Preoperculum. *Pt.* = Pterygoid.

The pterygoid is elongated and somewhat diamond-shaped; it tapers to a point both anteriorly and posteriorly. Between the anterior outer border of the pterygoid and the inner border of the maxilla there are two narrow palatine elements. A large ectopterygoid is in contact with the maxilla, and forms the outer border of the palate from the palatine back to the quadrate.

The inner borders of the pterygoid and ectopterygoid are united to an incompletely ossified metapterygoid. The inner margin of this bone is thin and very irregular, indicating that the mesial portion was not ossified. The metapterygoid is quite smooth, but all the other palatal bones bear large numbers of small, granular teeth. These are particularly abundant on the palatines and on the anterior portion of the ectopterygoid.

This palate shows a marked resemblance to certain of the Palæoniscid palates described by Watson (1925), and indicates that, like the cheek, the Catopterid palate retained the essential Palæoniscid structure with very slight modifications.

Sensory Canals of the Head.

The sensory canals run in the bones, and open to the exterior by numerous irregularly-placed pores. These are of fairly large size in the Catopteridæ, but often considerably finer in the Perleididæ. The course of the head-canals is the same in these families as in the Palæoniscidæ, and in no genus where the sensory canals are known is there any departure from this plan. The main canal comes up from the body, passes through the supracleithrum, tabular, and supratemporal, and reaches the border of the orbit, where it passes below as the infraorbital canal. There is a supraorbital canal which arises in the anterior part of the parietal or at the posterior border of the frontal, and runs forward, through the frontals and nasals, to anastomose eventually with the infraorbital canal. There are cross-commissures through the rostralo-postrostral and the tabulars. A hyomandibular branch is given off by the main canal, and traverses the preoperculum, close to its hinder border, before passing into the mandible. It runs the whole length of the mandible, keeping close to its posterior and ventral margins. Behind the supraorbital canal there are three lines of pit-organs, anterior, median, and posterior, and these lie either all in the parietal, as in *Perleidus*, or in the parietal and dermo-supraoccipital, as in *Helichthys*. In the latter genus the anterior line is not visible.

Appendicular Skeleton.

The membrane-bones of the shoulder-girdle are commonly extensively sculptured into a series of longitudinal ridges and furrows. The ornamentation tends to persist in these when it has been completely lost by the head-bones. Thus in *Cleithrolepis minor* the head-bones are thin and generally smooth, but the posterior part of the cleithrum is strongly ribbed. There are, presumably, post-temporals, supracleithra, cleithra, and clavicles in all forms, and postcleithral scales may be present, as in *Helichthys*. In the Catopteridæ the elements of the shoulder-girdle are all large and well-developed, the clavicles particularly so. The latter are not nearly so obvious in the Perleididæ, and are rarely seen. The large size of the clavicles and of the ventral limb of the cleithrum in the Catopteridæ is, no doubt, correlated with the loss of branchiostegal rays in that family.

The condition of the skeleton of the fins shows great differences in the two families, but is fairly uniform in each. The paired fins are most susceptible to change, and they may be in almost any condition. In the Catopteridæ the pelvic fin may be in the same condition as in certain Palæoniscids, a triangular, broad-based fin, with numerous almost completely articulated rays. Fulcra may be present or absent on the paired fins, but they are commonly present, and often very conspicuous. The size of the pectoral fins is variable, and the extreme is reached in *Dollopterus*, which had immense pectorals and was, apparently, a flying-fish.

The unpaired fins, the dorsal, anal, and caudal, are more amenable to classification. In the Catopteridæ they consist of a large number of usually fine lepidotrichia which outnumber the endoskeletal supports. They are completely articulated, and display a greater or less degree of branching.

In the Perleididæ, the lepidotrichia of the unpaired fins are proximally fused, and they normally equal the number of endoskeletal supports. The individual elements are free distally, and thus the rays are branched, but this type of branching is very much coarser than that displayed in the Catopteridæ and in the Palæoniscids. In the dorsal and anal fins the articulations are usually lost on the proximal fused area, so that this is perfectly stiff and rigid, but the distal portion of the rays is always articulated. In *Cleithrolepis* the rays are still completely articulated. The dermal rays of the tail show extensive branching, but they are always completely articulated.

It seems that the anterior part of a fish is most susceptible to change and the posterior part more conservative, for most modifications of structure are first apparent anteriorly. Thus in the fusion and stiffening of fin-rays the pectorals are invariably the first to be affected, and even in certain Palæoniscids it is found that the rays of the pectoral fin are continuous and lack articulations. In the Catopterids the pectoral fins are always the most advanced, the pelvics are less so, the dorsal and anal less again, and the caudal least of all. The median fins may be fulcrated or unfulcrated, but the former is the common condition.

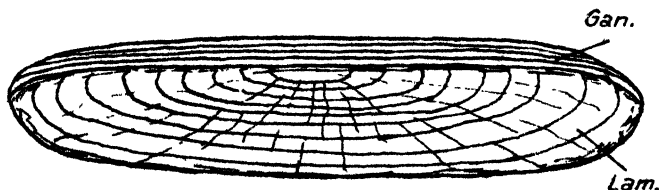
The tails of the Catopteridæ show every gradation from a condition which is just not completely heterocercal to one approaching an external homocercy. In *Dædalichthys* the scaly lobe extends almost to the tip, and it is only in perfect specimens that the incomplete heterocercy is observable. In *Helicthys* the lobe extends one-half to two-thirds of the way to the tip in different species. In the other Catopterid genera, *Catopterus* and *Dictyopyge*, the lobe is much reduced, but, considering the Upper Triassic age of these forms, this is not unexpected.

The Perleididæ all possess a very short scaly lobe. It is usually distinguishable, but it never extends to a third of the distance to the tip. It is most inconspicuous in *Colobodius* and *Dollopterus*.

Squamation.

The body is always covered by an armouring of thick, rhombic, ganoid scales which are frequently striated, and often possess denticulated posterior margins. They articulate by a peg-and-socket arrangement. The scales

Text-figure 18.



Drawing of a microscopic section of a scale of *Catopterus redfieldi*. $\times 30$.

Gan. = Ganoine. Lam. = Lamellated bone.

of *Cleithrolepis* and *Hydropessum* are much elongated, and their anterior borders are thickened. The ornament is of granules in the first genus and oblique striæ in the second. Enlarged scales are sometimes present in front of the fins and around the anus,

The Palæoniscid scale is formed of three horizontal layers—a thick, lamellated, bony layer below; a thinner, but dense, ganoin layer above; and between these a more or less attenuated cosmine layer. The cosmine layer is said to be an evolutionary relic from the Osteolepid type of cosmoid scale, which lacked ganoin but had a covering of cosmine on the outer surface. In *Lepidosteus* it is found that the cosmine layer has altogether vanished, and that the scale is made up of a thin ganoin layer above and a thick bony layer below.

A precisely similar condition has been attained in *Catopterus*, and it is probable that all the Catopterid and Perleidid fishes possessed this more modernised type of ganoid scale.

SUMMARY.

The foregoing discussion on this group of Palæoniscid derivatives reveals three main points:—

1. That the two families owe their similarity to a Palæoniscid origin and to the limited nature of the evolutionary changes in which they have subsequently been involved.

2. In consideration of the distinct differences in the structure of the skull, the lack of intermediate forms, and their co-existence side by side throughout Triassic time, it is probable that the two families arose from separate Palæoniscid stocks. Their many resemblances to the Palæoniscids are genuine, and denote a true relationship.

3. The resemblances to the Semionotidæ are, on the other hand, clearly due to convergence, for the structure of the head in Semionotids is much modified from that of these or any of the older groups. Stensiö's suggestions that the Semionotidæ may have been derived from the Catopterid-Perleidid group is very highly improbable, for the Semionotids had already arisen as a separate offshoot from the Palæoniscids in Mid-Permian time, apparently long before either Catopterids or Perleidids had come into existence.

The essential differences between the Catopteridæ and Perleididæ may be summarized as follows:—

CATOPTERIDÆ.

1. The parietals are small and triangular or irregular in shape. Dermo-supraoccipitals are commonly present.
2. The nasals are rather small, and do not enter into the border of the orbit.
3. The suspensorium is usually oblique.
4. The teeth are always small, sharp, and conical.
5. The postfrontal is of characteristic shape, and abuts against the supratemporal. The intertemporal is absent.
6. The lepidotrichia are numerous in the unpaired fins, and outnumber the endoskeletal supports.
7. The rays of the dorsal and anal fins are always completely jointed.
8. The scaly lobe of the tail may extend almost to the tip.
9. Branchiostegal rays are absent,

PERLEIDIDÆ.

1. The parietals are large and almost invariably square, although they may be quadrangular. Dermo-supraoccipitals are absent.
2. The nasals are relatively large, and enter into the border of the orbit.
3. The suspensorium is usually vertical, and may be slightly forwardly directed.
4. The teeth are usually long and cylindrical, and may be altogether absent.
5. The intertemporal is present, and lies between the supratemporal and the postfrontal.
6. The lepidotrichia are few in the unpaired fins, and essentially correspond to the number of endoskeletal supports.
7. The rays of the dorsal and anal fins are usually fused proximally and jointed distally.
8. The scaly lobe of the tail never extends to one-third of the distance toward the tip.
9. Branchiostegal rays are present,

On the other hand, it is found that the two families have certain characters in common, and that they share these with the Palæoniscidæ. These characters, which are enumerated below, are the relics of their Palæoniscid ancestry.

The maxilla is a large and conspicuous element, deep behind and shallow in front, and posteriorly, or dorso-posteriorly, firmly united to a large preoperculum. These bones together form the essential covering of the cheek.

The interopercular bone so characteristic of higher groups is not developed, and the gill-chamber is covered only by an operculum and suboperculum.

The orbit is still large and anteriorly placed, and has not departed from the arrangement favoured by the Palæoniscidæ.

The system of sensory canals in the head is exactly similar in the Catopteridæ, Perleididæ, and Palæoniscidæ; and it is clear that the former groups have derived it from the Palæoniscids, and retained it, without modification, throughout their history.

The resemblances of the Perleididæ to the Semionotidæ, and, to a less extent, to the Pholidophoridæ, are superficially striking, but remain none the less superficial. The resemblance is in general appearance and in the distribution and condition of the fins. In both the Perleididæ and Semionotidæ the body may be normally fusiform, but frequently shows tendencies toward depth, and in some forms becomes exceedingly deep. The gape is never very wide, and the suspensorium is more or less straight. There is a covering of thick, rhombic, ganoid scales. The fins are similarly distributed, and the dermal rays are much branched, and equal in number the endoskeletal supports. The tails in the two groups have attained an exactly similar condition, with the scaly lobe very much reduced, almost attaining an external homocercy.

These two groups thus provide an interesting case of parallel evolution between entirely different stocks, and the result is confusing. Without a knowledge of the structure of the skull it is often difficult and, may be, well nigh impossible, to decide to which of these families a fish belongs.

Bodies with imperfect heads form the bulk of fossil fish material, and it is not surprising to find that the Perleididæ had completely escaped notice until 1910, when Alessandri took *Semionotus altolepis* from the Semionotidæ, called it *Perleides*, and placed it in the Catopteridæ. This was a beginning, and it was found subsequently that other species which had been supposed to be members of the Semionotidæ or Pholidophoridæ were misplaced, and their removal to another group became a necessity. Along with these forms new ones have been described, and are here grouped together as the Perleididæ. It is likely that the Semionotidæ and Pholidophoridæ still contain Perleidid forms, and further investigation will effect a removal of these to their rightful place in the new family.

8. COMPARISON OF FAUNAS AND OUTLINE OF THE EVOLUTION OF BONY FISHES IN TRIASSIC TIME.

A comparison of Upper Permian and Lower Liassic faunal lists is sufficient to indicate that the Triassic period was an important and critical one in piscine evolution. In the Upper Permian the bony fishes were, with one exception (*Acentrophorus*), of an ancient and typically Palæozoic type, consisting largely of Palæoniscids. In the Lower Liassic the Palæoniscids are barely represented; the more modern type of bony fishes, the higher Ganoids, are dominant, and near relatives of the Teleosts are already in existence.

The profound modification of the Palæoniscid head, to give rise to the higher Ganoids and Teleosts, is one of the most important events in the history of bony

fishes. It certainly furnishes the most important break in the Actinopterygii—that between the Palæoniscids and their allies, fishes with a large, firmly-fixed, deep maxilla and large preoperculum, and the higher bony fishes, those with a small, freed maxilla and a very much reduced preoperculum. The members of the latter group may or may not have ganoid scales.

The differences in cranial structure between a Semionotid or Pholidophoid and a Leptolepid are not great, but the differences between any of these and a Palæoniscid are obvious and significant. The term "Higher Ganoids" in this paper refers to the Semionotidæ, Pholidophoridæ, etc.; all those Ganoid families possessing the reduced maxilla and preoperculum and the other characters which differ so much from and which replaced those that had been prominent in the Palæoniscidæ.

A good deal has been written on Triassic fish-remains from time to time, and there is now enough material at hand to attempt to give an outline of the evolutionary changes which took place during that period. The fact that the Triassic rocks yield two distinct types of fish-fauna—freshwater and marine—may tend to introduce slight complications, and to obscure the main evolutionary trend. A freshwater fauna, for a variety of reasons, must always show some differences from a contemporaneous marine fauna.

The fresh waters are often the last haven of groups which are on the wane, and when this is the case the fauna of an inland water may take on an unusually ancient appearance.

There may be sporadic migrations from the sea to the inland waters, followed by periods, greater or less, of isolation due to the cutting off of the line of supply by earth-movements or some other causes. In this way it is possible to have a few, quite unrelated forms left to evolve in their own way, and in time producing an unbalanced and peculiar fauna.

The new forms which evolved in great numbers during the Triassic did so mainly in the sea, and presumably did not spread to the fresh waters, at least not as a body, but only sporadically as individuals.

In view of these arguments the marine faunas will be considered first. The important freshwater faunas can be discussed separately.

There is a large marine fauna from the Lower Triassic of Spitzbergen. From the Middle Triassic there are the faunas of the German Muschelkalk and the Lettenkohl group of the Alpine Trias. The Alpine Trias also yields a number of representative Upper Triassic Marine faunas. The faunal lists in the accompanying table were derived from various sources. Those of the Upper Permian and Lower Liassic were compiled largely from the British Museum Catalogue of Fossil Fishes; the Lower Triassic list is from Stensiö (1921); the Lettenkohl and Haupt-dolomite lists from Allesandri (1910); and the Muschelkalk list from Stolley (1920). Elasmobranchs have been omitted in all cases, and slight modifications have been introduced in the placing of the genera into families.

If these faunas are placed in order of age between those of the Upper Permian and the Lower Lias (see text-fig. 19), it is seen that it is during the Middle Triassic time that the old type of structure is abandoned and the new is introduced. From the Lower Carboniferous to the Lower Trias Palæoniscids were dominant, but in the Lettenkohl group and the Upper Triassic the bony fish fauna is essentially of higher Ganoids. From that time onwards Palæoniscids are scarcely represented, and are very rare generically, specifically, and individually, until they fade out in the Cretaceous.

The Muschelkalk fauna, lying between those of the Lower Trias and the Lettenkohl, is of great interest and importance. In it is found that neither the Palæoniscids nor the higher Ganoids are overwhelmingly abundant, although both are well and about equally represented. They both appear to be outnumbered by a fairly extensive development of the Perleididæ, and, as the accompanying list shows, it would appear that the Perleididæ made the greatest contribution to the bony fish fauna of the Muschelkalk sea.

Text-figure 19.

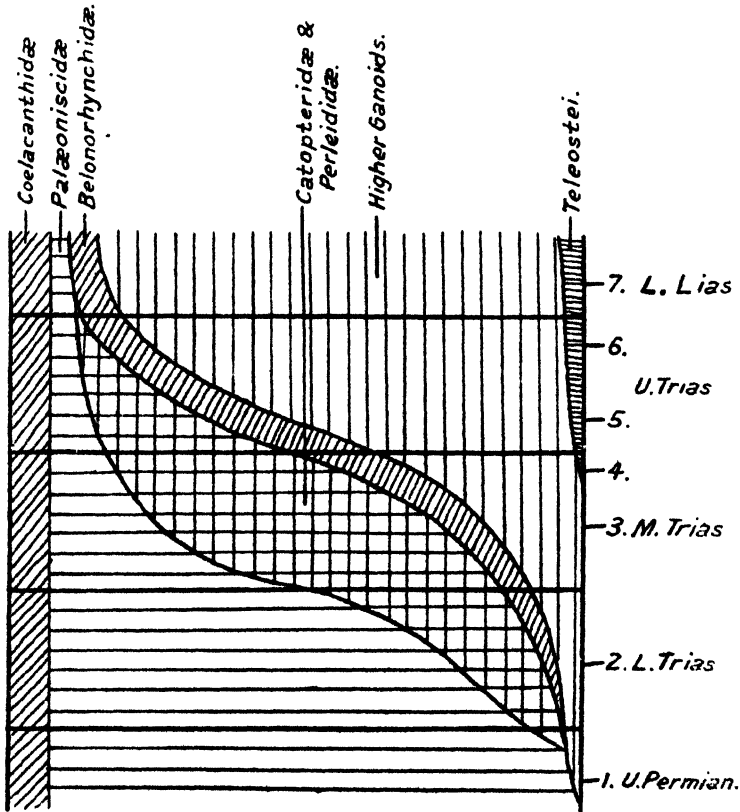


Diagram to illustrate the evolution of the bony fishes during the Triassic period. The numbers at the right-hand side indicate the horizons from which the faunas listed in the accompanying table were obtained.

Thus, between the decaying of Palæoniscid supremacy and the rise of the higher Ganoids these peculiar families, the Catopteridæ and Perleididæ, became widespread, and for a fleeting space appear to have attained a position of dominance among the bony fishes.

The Catopteridæ was the more primitive, and less highly developed of these two families; its occurrences appear to have been sporadic and its habitat restricted. The only known occurrences of this family are in the Karroo System of South Africa, the Newark beds of North America, and the

TABLE TO ILLUSTRATE THE EVOLUTION OF

| KUPFERSCHIEFER AND MARL SLATE (UPPER PERMIAN). | LOWER TRIASSIC, SPITZBERGEN. | GERMAN MUSCHELKALK. | EXTREME UPPER MIDDLE TRIASSIC, PERLEDO. |
|--|---|--|---|
| Cœlacanthidæ. <i>Cœlacanthus granulatus</i> | Cœlacanthidæ. <i>Wimania sinuosa.</i> <i>Sassenia tuberculata.</i> <i>Azelia robusta.</i> " <i>elegans.</i> <i>Myliacanthus lobatus.</i> " <i>spinosus.</i> <i>Scleracanthus asper.</i> | Dipnoi. <i>Ceratodus.</i> | Cœlacanthidæ. <i>Heptanema paradoxa.</i> |
| Palæoniscidæ. <i>Palæoniscus freislebeni.</i> " <i>magnus.</i> " <i>macropomus.</i> " <i>longissimus.</i> " <i>macrophthalmus.</i> | Palæoniscidæ. <i>Birgeria mougeoti.</i> <i>Glaucolepis gyrolepidoides.</i> <i>Pygopterus de geeri.</i> <i>Boreosomus arcticus.</i> " <i>reuter-</i> " <i>skioldi.</i> <i>Acrorhabdus bertili.</i> " <i>asplundi.</i> " <i>lati-</i> " <i>striatus.</i> | Palæoniscidæ. <i>Gyrolepis alberti.</i> " <i>ornatus.</i> " <i>agassizi.</i> " <i>quenstedti.</i> <i>Urolepis</i> sp. | Palæoniscidæ. <i>Urolepis macroptera.</i> " <i>microlepidota.</i> |
| Pygopteridæ. <i>Pygopterus humboldti.</i> <i>Acrolepis sedgwicki.</i> " <i>exsculpta.</i> | Perleididæ. <i>Perleidus woodwardi.</i> | Perleididæ. <i>Colobodus gogolinensis.</i> " <i>frequens.</i> " <i>rarius.</i> " <i>maximus.</i> " <i>konigi.</i> <i>Dollopterus rotans.</i> " <i>brunsvicensis.</i> " <i>subser-</i> " <i>ratus.</i> " sp. | Perleididæ. <i>Perleidus altolepis.</i> <i>Colobodus</i> sp. |
| Platysomidæ. <i>Platysomus gibbosus.</i> <i>Globulodus macrurus.</i> | Belonorhynchidæ. <i>Saurictis ornatus.</i> " <i>rimani.</i> " <i>hamiltoni.</i> " <i>elongatus.</i> | Belonorhynchidæ. <i>Belonorhynchus robustus.</i> | Belonorhynchidæ. <i>Belonorhynchus robustus.</i> |
| Dorypteridæ. <i>Dorypterus hoffmanni.</i> | | Semionotidæ. <i>Semionotus balsami.</i> | Semionotidæ. <i>Semionotus balsami.</i> |
| Semionotidæ. <i>Acentrophorus glaphyrus.</i> | | Semionotidæ. <i>Eosemionotus vogeli.</i> " sp. | Macrosemiidæ. <i>Ophiopsis lepturus.</i> " <i>larcensis.</i> |
| | | Pholidophoridæ. <i>Pholidophorus</i> sp. | Eugnathidæ. <i>Eugnathus hermesi.</i> " <i>trotii.</i> <i>Heterolepidotus pectoralis.</i> " <i>serratus.</i> " <i>tarra-</i> " <i>mellii.</i> " <i>brevis.</i> " <i>bellottii.</i> <i>Allolepidotus nothoso-</i> " <i>moide.</i> " <i>bellottii.</i> " <i>rüppellii.</i> |
| | | | Pholidophoridæ. <i>Pholidophorus curionii.</i> " <i>oblongus.</i> <i>Protalecites porroi.</i> |
| | | | Leptolepidæ. <i>Leptolepis</i> sp. |

BONY FISHES DURING THE TRIASSIC PERIOD.

| LOWER UPPER TRIASSIC, BESANO. | UPPER UPPER TRIASSIC, HALLEIN. | LOWER LIASSIC, LYNE REGIS. |
|-----------------------------------|--------------------------------------|-------------------------------------|
| Cœlacanthidæ. | Belonorhynchidæ. | Cœlacanthidæ. |
| <i>Undina</i> sp. | <i>Belonorhynchus krambergeri.</i> | <i>Undina</i> sp. |
| Palæoniscidæ. | Semionotidæ. | Palæoniscidæ. |
| <i>Urolepis</i> sp. | <i>Semionotus kapffi.</i> | <i>Oxygnathus ornatus.</i> |
| | " <i>Colobodus</i> " <i>ornatus.</i> | <i>Centrolepis aspera.</i> |
| | " <i>decoratus.</i> | <i>Coccolepis liassica.</i> |
| Perleididæ. | <i>Dapedius</i> sp. | |
| <i>Colobodus bassani.</i> | <i>Spaniolepis ovalis.</i> | |
| <i>Meridensia meridensis.</i> | | Belonorhynchidæ. |
| Belonorhynchidæ. | Macrosemiidæ. | <i>Belonorhynchus acutus.</i> |
| <i>Belonorhynchus curionii.</i> | <i>Ophiopsis attenuata.</i> | " <i>brevisrostris.</i> |
| " <i>stoppanii.</i> | | Chondrosteidæ. |
| " <i>intermedius.</i> | Eugnathidæ. | <i>Chondrosteus acipenseroides.</i> |
| Macrosemiidæ. | <i>Heterolepidotus dorsalis.</i> | " <i>pachyurus.</i> |
| <i>Ophiopsis bellotti.</i> | " <i>parrulus.</i> | |
| | Pycnodontidæ. | Semionotidæ. |
| Eugnathidæ. | <i>Mesodon hoferi.</i> | <i>Dapedius politus.</i> |
| <i>Heterolepidotus gibbus.</i> | | " <i>radiatus.</i> |
| <i>Ptycholepis barboi.</i> | Pholidophoridæ. | " <i>colei.</i> |
| | <i>Pholidophorus latiusculus.</i> | " <i>punctatus.</i> |
| Pholidophoridæ. | " sp. | " <i>granulatus.</i> |
| <i>Pholidophorus barazzettii.</i> | | Eugnathidæ. |
| " <i>besanensis.</i> | | <i>Eugnathus orthostomus.</i> |
| <i>Peltopteleurus splendens.</i> | | " <i>philpotæ.</i> |
| | | " <i>minor.</i> |
| | | " <i>serratus.</i> |
| | | " <i>altus.</i> |
| | | <i>Heterolepidotus latus.</i> |
| | | <i>Ptycholepis gracilis.</i> |
| | | " <i>curta.</i> |
| | | " <i>monilifer.</i> |
| | | " <i>minor.</i> |
| | | <i>Osteorhynchus macrocephalus.</i> |
| | | " <i>granulatus.</i> |
| | | <i>Caturus heterurus.</i> |
| | | " <i>latipennis.</i> |
| | | " <i>agassizi.</i> |
| | | " <i>chiroles.</i> |
| | | Pholidophoridæ. |
| | | <i>Pholidophorus bechei.</i> |
| | | " <i>pachysomus.</i> |
| | | " <i>caudalis.</i> |
| | | " <i>crenulatus.</i> |
| | | " <i>limbatus.</i> |
| | | Leptolepidæ. |
| | | " <i>Leptolepis</i> " sp. |

Hawkesbury Series of New South Wales *. These are all freshwater deposits, and suggest that the Catopteridæ may have been a freshwater family. This suggestion is not stressed because it rests very largely on negative evidence, and it would not be surprising if Catopterids were found in a marine fauna. It is, however, quite certain that if they did inhabit the seas they were by no means common, for they do not appear to enter into the composition of any of the well-known Triassic marine faunas. In any case their distribution is very odd, for in their short and obscure history it became almost world-wide.

The Perleididæ were a more highly developed and apparently a much more successful family. They were conspicuous members of the faunas of both the seas and the fresh waters throughout the Triassic period. They reached their acme in the Middle and Upper Triassic seas, where they attained their greatest size, and certain members developed immense pectoral fins and became flying-fish. Their distribution was world-wide, freshwater forms being known from Europe, South Africa, and Australia, and marine forms from Europe, Spitzbergen, and, presumably, Canada, for certain fishes described by Lambe as Palæoniscids probably belong to this family.

Although there are odd occurrences of presumably freshwater fishes, very rarely in the continental Bunter, and commonly in the Keuper of both Britain and the Continent, there are only three occurrences of Triassic freshwater fishes that are sufficiently varied, or extensive, to repay consideration here. These are found in the Karroo beds of South Africa, the Hawkesbury Series of Australia, and the Newark beds of eastern North America.

The Lower Triassic Karroo fauna has been extensively commented upon in the previous parts of this paper, and, considering its age, it presents few peculiarities. Apart from the presence of one Cœlacanth species, all the bony fishes are either Palæoniscids or members of the Catopterid-Perleidid group. The proportions in which the members of the two groups occur is unusual, for although it is at a low horizon in the Triassic, the Palæoniscids appear to be, both specifically and individually, much more rare than the Catopterids and Perleidids.

These proportions may be accounted for by the assumption that a certain number of forms got into this inland water, or waters, and became isolated there. They were then left to establish a balance among themselves, and it is found, as might be expected, that the most highly evolved families become dominant. The commonest fish is the Perleidid *Cleithrolepis minor*, and that the next most common is also a Perleidid, *Meidiichthys*. The Catopterids are not so numerous individually, but the unstable genus *Helicthys* appears to have flourished in this environment and produced a variety of species. The Palæoniscids, although a fair number of different forms were present, were not conspicuous and all species are individually rare.

The various beds of the Hawkesbury Series of New South Wales show varying characters, but are, presumably, all freshwater. Palæoniscids occur, sometimes abundantly, and they, along with certain "Catopterids," import to the fauna a fairly old appearance. Several forms were described and assigned to the Semionotidæ and Pholidophoridæ, but much new material has recently come to light, and these fishes are now being worked over again. The nomenclature will be revised, and probably much modified. In view of this, it is not proposed to enter into a discussion of the relationships of the Australian faunas at present.

The only other outstanding freshwater fauna is that of the Newark beds

* The Rev. R. T. Wade, who is engaged in a study of the fossil fishes of the Hawkesbury Series, has kindly informed me that there is a new Catopterid genus in his collection.

of the eastern United States, which is probably of Upper Triassic age. It is peculiar in many respects, and is composed of a very limited number of genera. There is one rare *Cœlacanth*, two *Catopterids*, one of which, *Dictyopyge*, is quite rare. *Catopterus* itself is abundant. *Semionotus* is present in great profusion, both specifically and individually. The only other genus represented is *Ptycholepis*, which is very rare indeed.

Thus the fauna is essentially composed of *Catopterus* and *Semionotus*, and it would appear to have suffered isolation, for the latter genus went on and developed a large number of endemic species, as freshwater fishes often do. A comparison of this fauna with those of the Upper Triassic of the Continent shows more differences than resemblances, for although the presence of *Semionotus* is a link, there is a wholesale lack of common Upper Triassic forms from the Newark fauna. The *Catopterids*, which form almost half of the North American fauna, are not known to occur in the Middle and Upper Triassic of Europe. In spite of this, the North American fauna may well be contemporaneous with the Upper Triassic faunas of Europe, and the very limited variation in the Newark fishes is one that is neither unusual nor unexpected in a freshwater fauna.

REFERENCES.

[For an almost complete bibliography of the literature on Triassic fishes, see Stensiö (1921).]

- ALESSANDRI, G. DE. 1910. Studi sui pesci triasici della Lombardia. Milano, Soc. Ital. Sci. Nat. Mus. Civ. Stor. Nat. Mem. vol. vii.
- ANDERSSON, E. 1916. Ueber einige Trias-fische aus der Cava Trefontane, Tessin. Upsala, Geol. Inst. Bull. vol. xv.
- BROOM, R. 1905. On a Species of *Calacanthus* from the Upper Beaufort Beds of Aliwal North. Rec. Albany Mus. Grahamstown, S. Africa, vol. i.
- BROOM, R. 1909. The Fossil Fishes of the Upper Karroo Beds of South Africa. Ann. S. African Mus. vol. vii.
- DAMES, W. 1888. Die Ganoiden des deutschen Muschelkalkes. Palæont. Abhandl. Bd. iv. Heft 2.
- DEECKE, W. 1889. Ueber fische aus verschiedenen Horizonten der Trias. Palæontographica, Bd. xxxv.
- EASTMAN, C. R. 1904-1905. The Triassic Fishes of New Jersey. Geol. Surv. of New Jersey. Ann. Report, 1904.
- EASTMAN, C. R. 1911. Triassic Fishes of Connecticut. State of Conn., St. Geol. Nat. Hist. Surv. Bull. 18.
- EASTMAN, C. R. 1914. Notes on Triassic Fishes belonging to the families *Catopteridae* and *Semionotidae*. Carnegie Mus. Annals, vol. ix.
- EGERTON, P. M. G. 1864. On some Icthyolites from New South Wales. Quart. Journ. Geol. Soc. vol. xx.
- GORJANOVIC-KRAMBERGER, D. 1905. Die Obertriadische Fischfauna von Hallein in Salzburg. Betr. Palæont. Geol. Oesterr.-Ungarn, vol. xviii.
- LAMBE, L. M. 1916. Ganoid Fishes from near Banff, Alberta. Roy. Soc. Canada, Trans. ser. 3, vol. x. sect. iv.
- NEWBERRY, J. S. 1888. Fossil Fishes and Fossil Plants of the Triassic Rocks of the Connecticut Valley. U.S. Geol. Surv. Mon. vol. xiv.
- STENSIÖ, E. A. 1921. Triassic Fishes from Spitzbergen.—Part I. Vienna, 1921.
- STOLLEY, E. 1920. Beiträge zur Kenntnis der Ganoiden des deutschen Muschelkalkes. Palæontographica, Bd. lxxiii.
- TRAQUAIR, R. H. 1877-1911. The Ganoid Fishes of the British Carboniferous Formations.—Part I. Palæoniscidae. London Palæontographical Society.
- TRAQUAIR, R. H. 1879. On the Structure and Affinities of the *Platysomidae*. Trans. Roy. Soc. Edin. vol. xxix. part 1.

- WATSON, D. M. S. 1925. The Structure of certain Palæoniscoids and the Relationships of that Group with other Bony Fish. Proc. Zool. Soc. London.
- WATSON, D. M. S. 1928. On some Points in the Structure of Palæoniscid and Allied Fish. Proc. Zool. Soc. London.
- WOODWARD, A. S. 1890. The Fossil Fishes of the Hawkesbury Series at Gosford, New South Wales. Geol. Survey Mem., Palæontology, no. 4.
- WOODWARD, A. S. 1893. Further Notes on Fossil Fishes from the Karroo Formation of South Africa. Ann. & Mag. Nat. Hist. ser. 6, vol. xii.
- WOODWARD, A. S. 1908. The Fossil Fishes of the Hawkesbury Series at St. Peters, New South Wales. Geol. Survey Mem., Palæontology, no. 10.

EXPLANATION OF THE PLATES.

[The plates are prepared from untouched photographs of specimens in Prof. Watson's collection, except those of *Dictyopyge*, which are from a specimen in the collection of the American Museum of Natural History, New York.]

PLATE I.

- Fig. 1. Tail of *Calacanthus africanus* (P. 1 c). $\times \frac{3}{4}$.
2. *Dicelopyge macrodentatus* (P. 8). $\times \frac{1}{2}$.
3. *Dicelopyge lisocephalus* (P. 13 e). About natural size
4. *Dmdalichthys higginsi* (P. 6 a). $\times \frac{1}{2}$.

PLATE II.

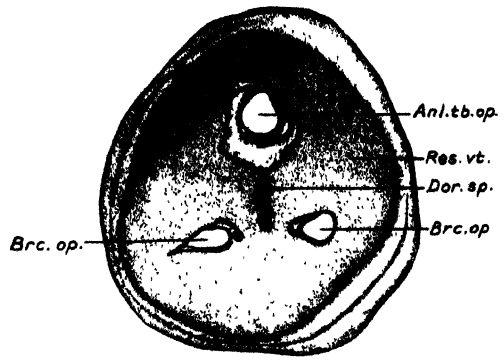
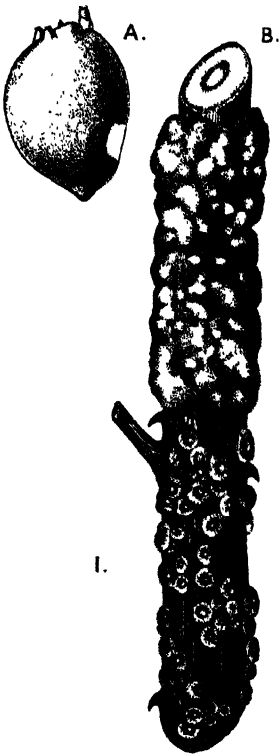
- Fig. 1. *Helicthys elegans* (P. 13 a). Almost natural size.
2. *Helicthys elegans* (P. 13 a). Magnified view of the skull showing the top and side. $\times 2\frac{1}{2}$.
3. Almost complete specimen of *Helicthys stegopyge* (P. 12 v), and tail of *Helicthys obesus* (P. 12 c). About natural size.

PLATE III.

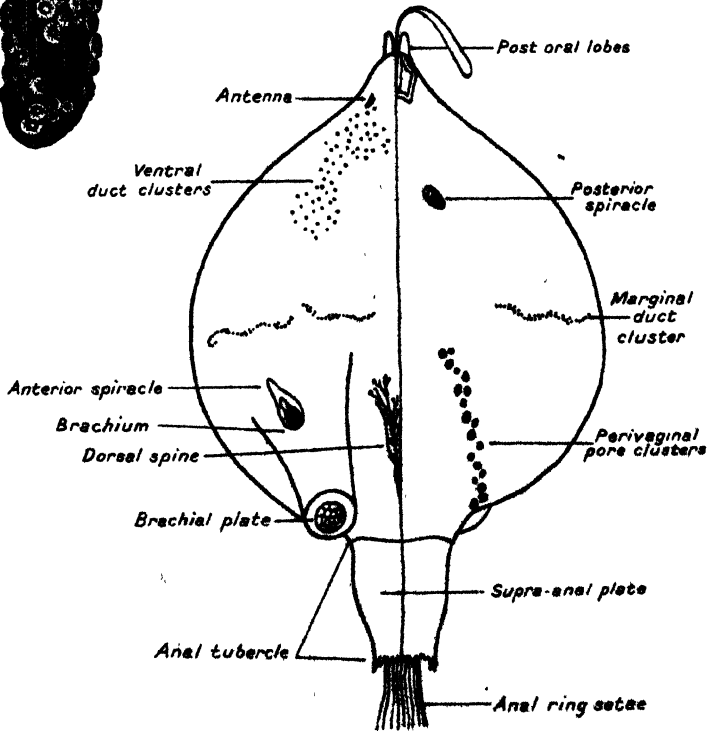
- Fig. 1. Tail of *Helicthys obesus* (P. 12 c). $\times 1\frac{1}{2}$.
2. *Helicthys ctenipteryx* (P. 12 a). Natural size.
3. *Helicthys grandipennis* (P. 14). Natural size. The fins are all imperfect in this specimen, but their comparatively great size is easily seen on the counterpart.
4. Palate, lower jaw, and opercular apparatus of *Helicthys* (P. 7 b). $\times 3$.

PLATE IV.

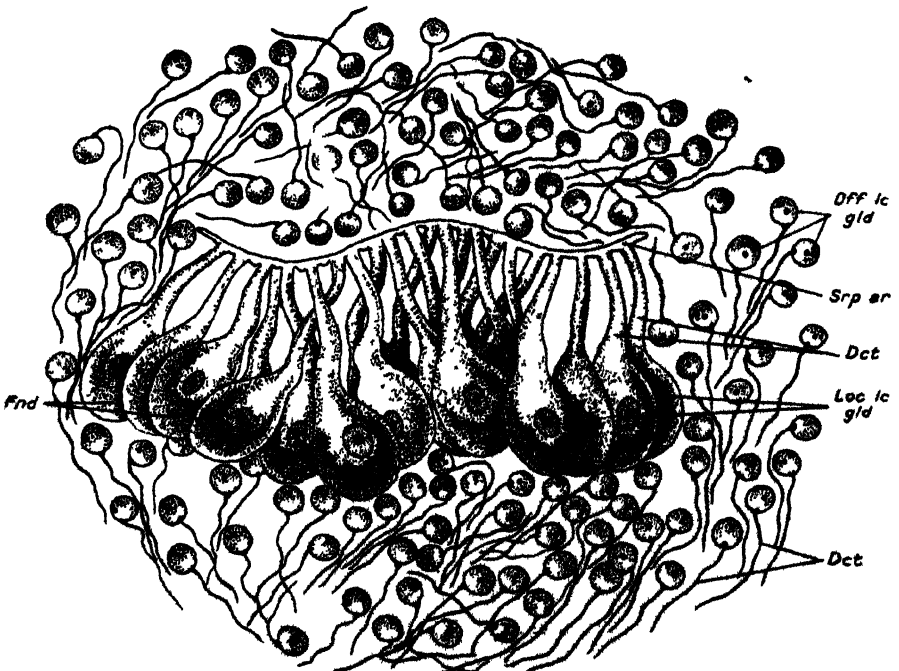
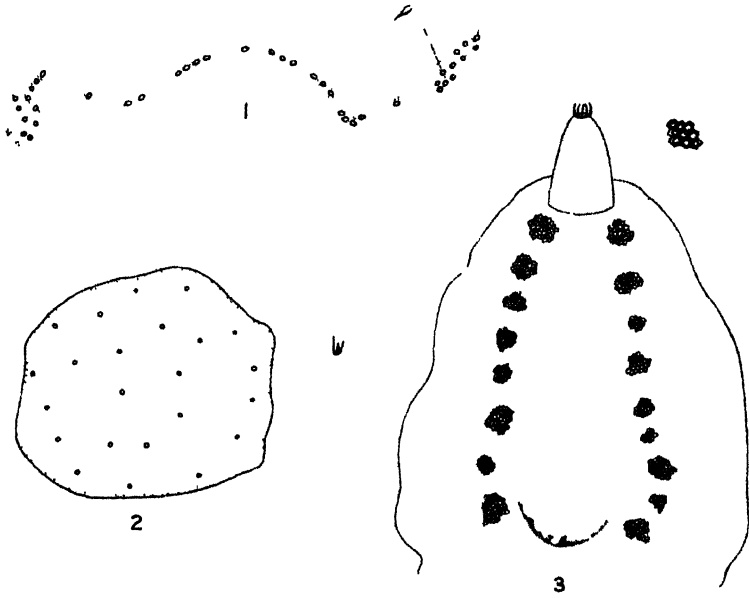
- Fig. 1. *Meidiichthys browni* (P. 20). Natural size.
2. *Dictyopyge decipiens* (654 a). $\times \frac{1}{2}$.
3. *Dictyopyge decipiens* (654 a). $\times 2\frac{1}{2}$. Magnified view of skull (for key, see text-fig. 16).



2.



3.



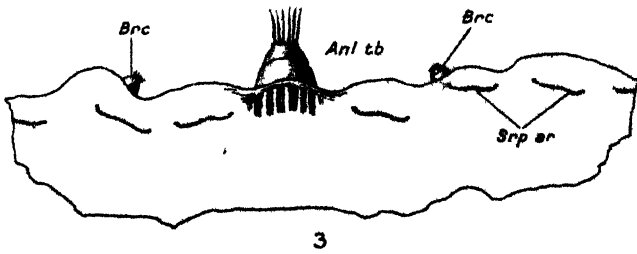
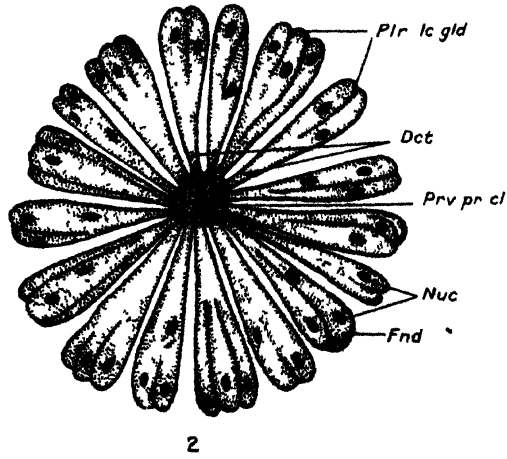
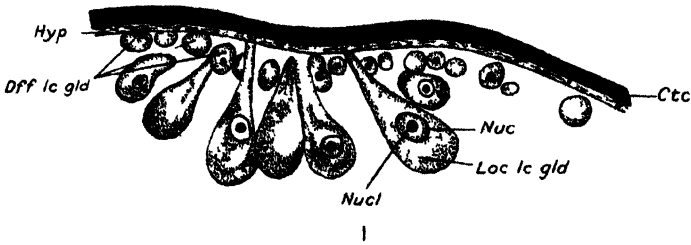
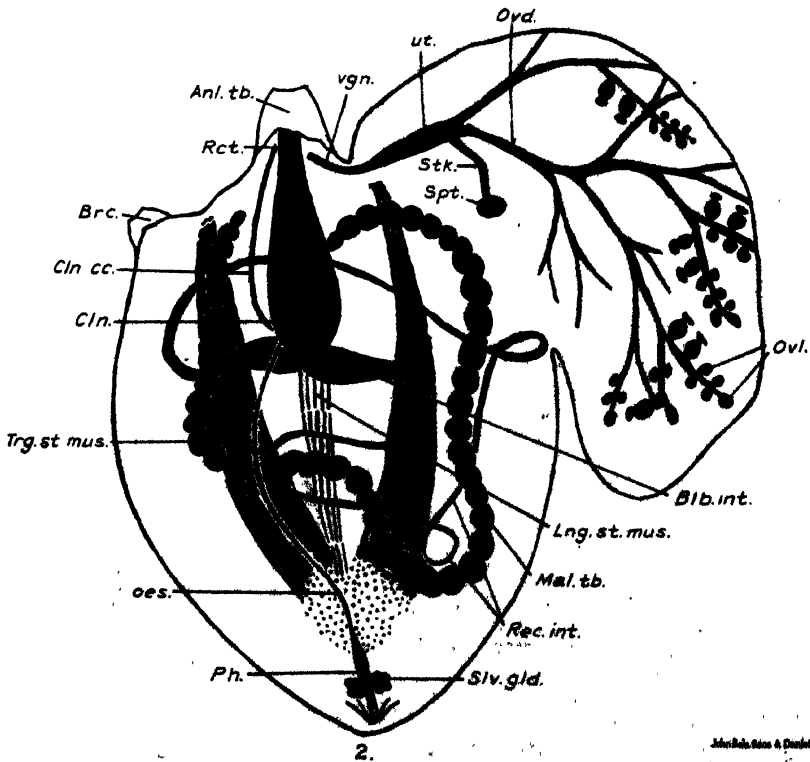
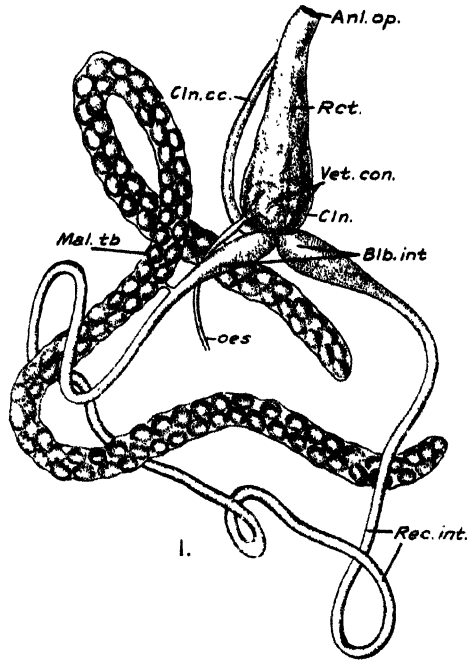
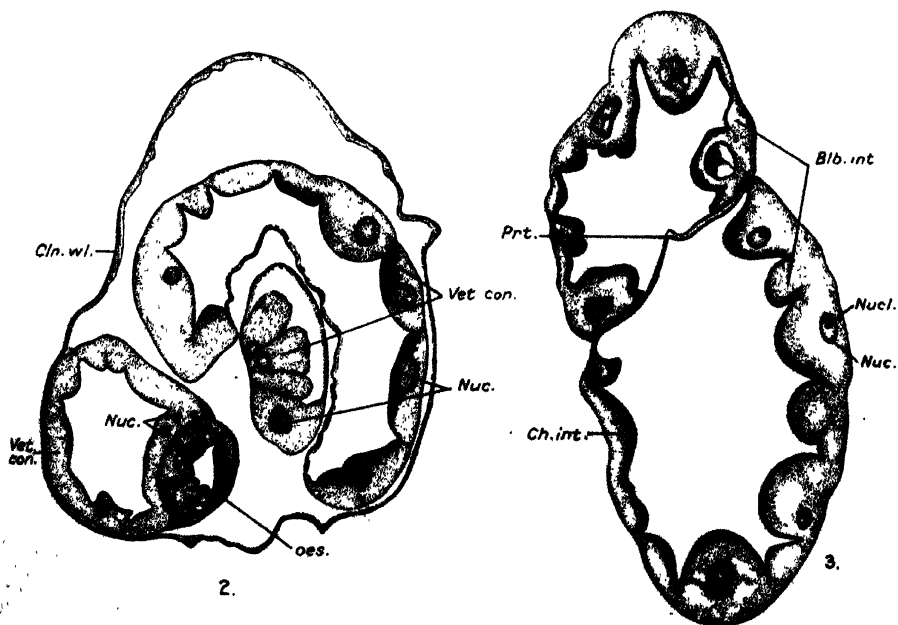
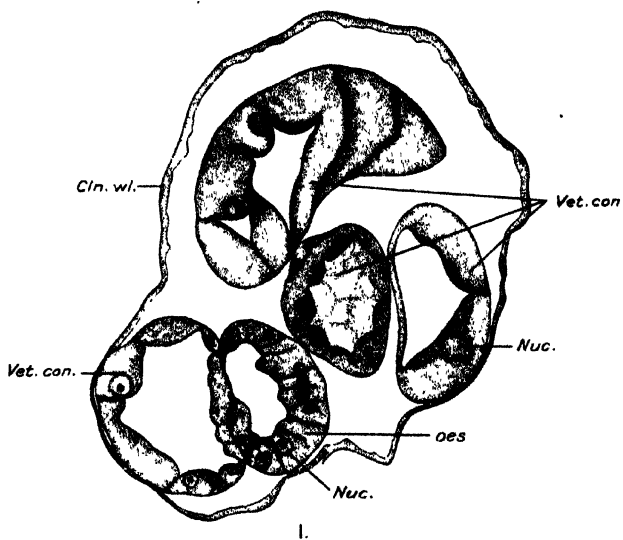
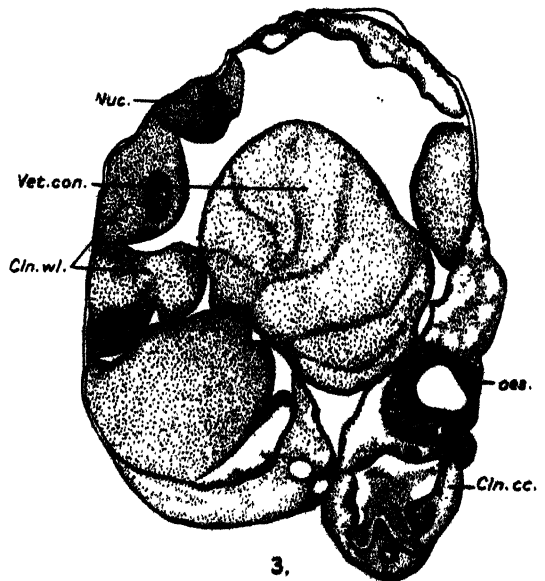
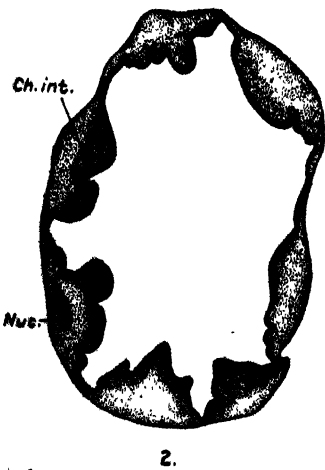
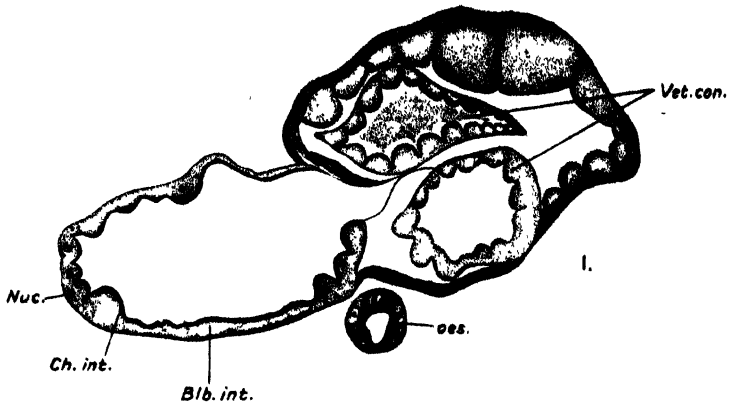


Illustration by Dr. A. K. Misra, B.A. (Hons.) I.C.S.

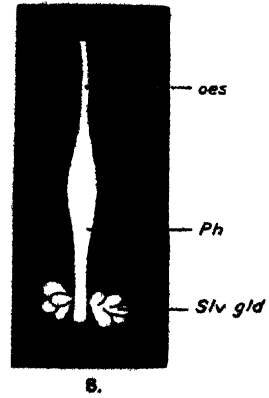
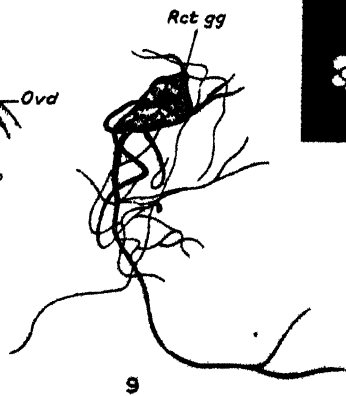
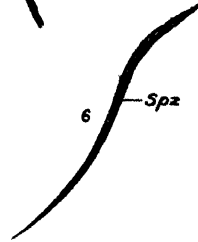
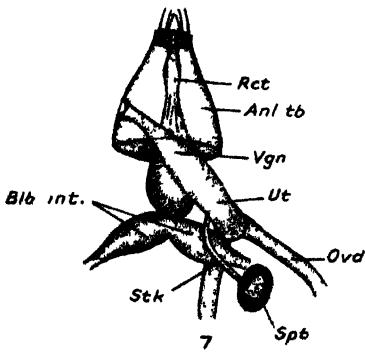
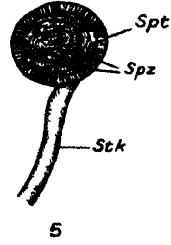
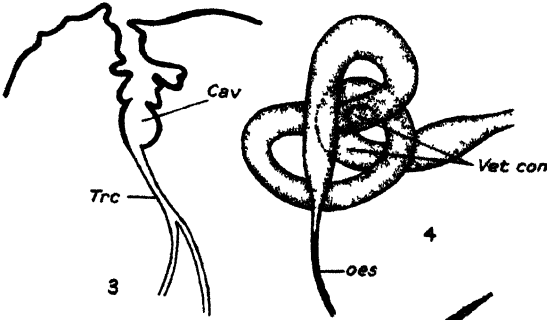
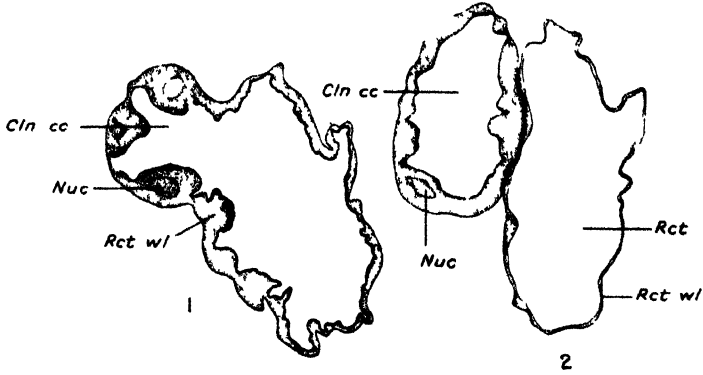


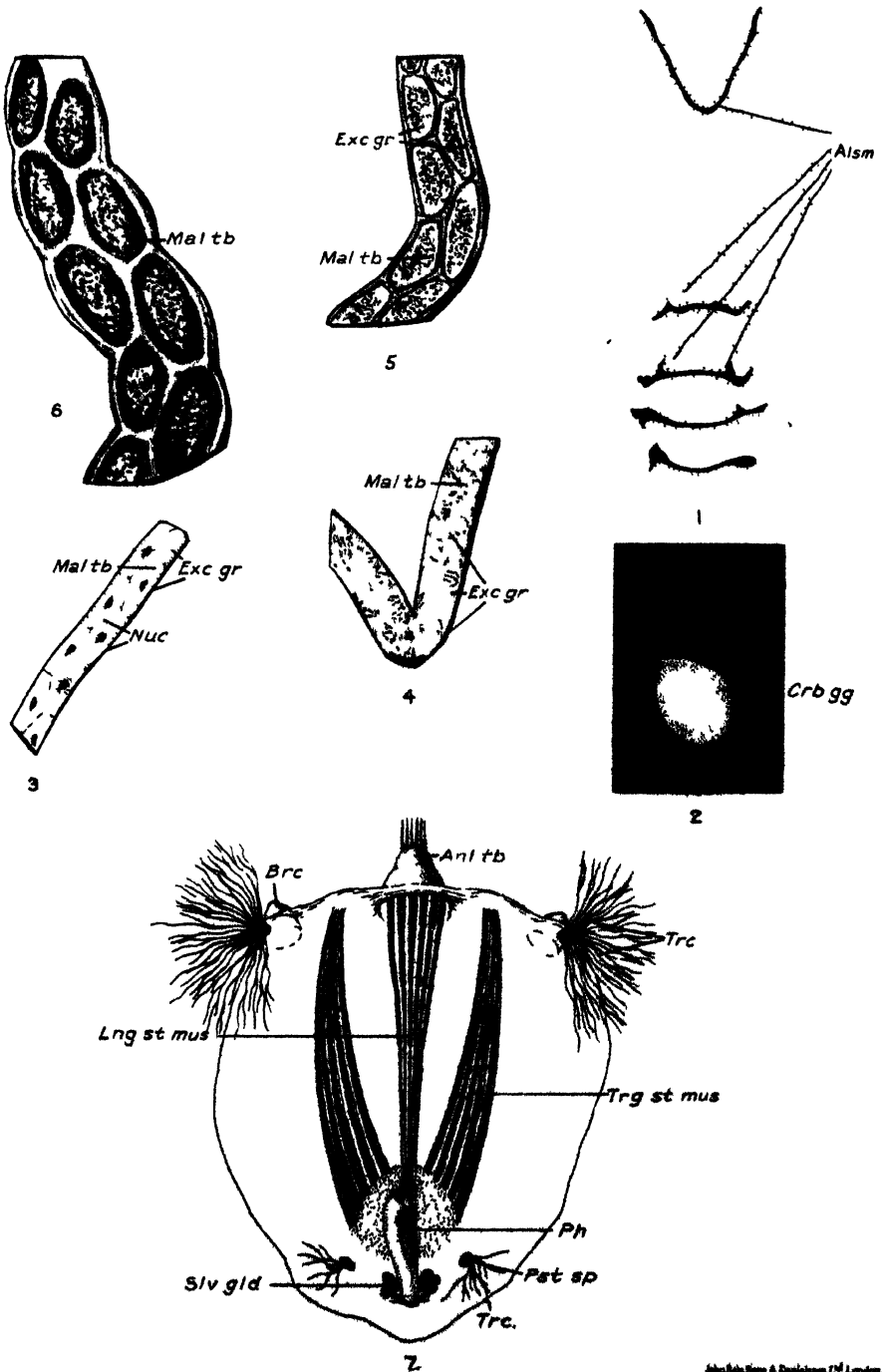


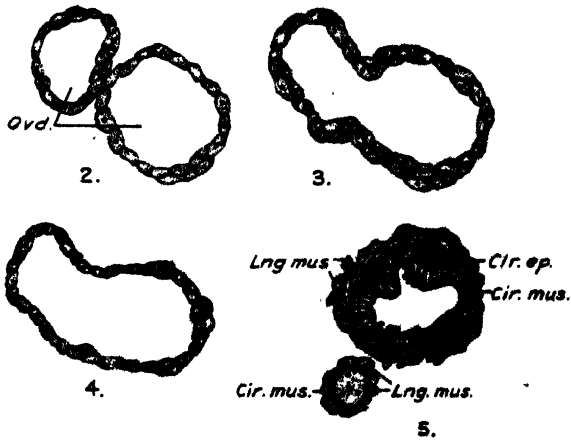
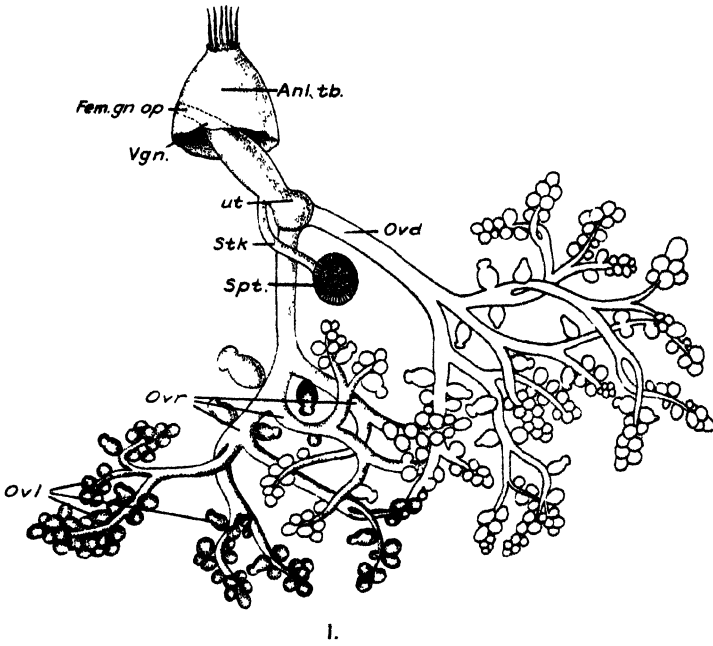
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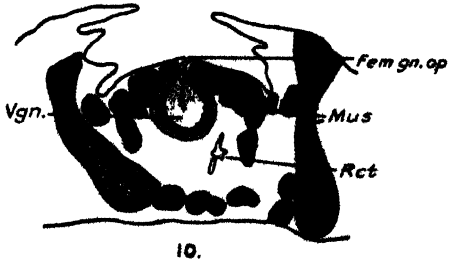
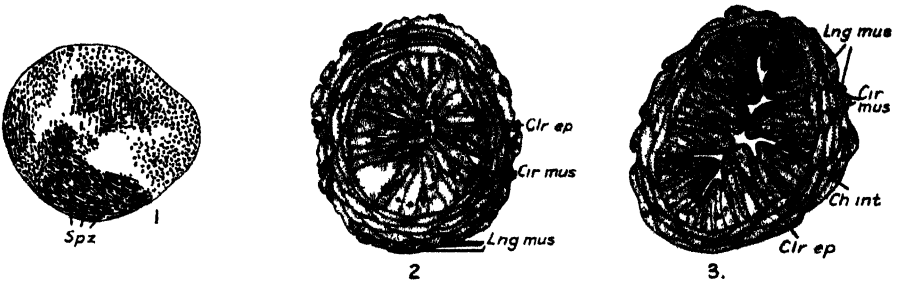
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14. On the Internal Anatomy of the Female Lac Insect, *Laccifer lacca* Kerr (Homoptera : Coccidæ) *. By AWADH BEHARI MISRA, D.Sc., F.Z.S., from the Department of Zoology, Lucknow University, India.

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INTRODUCTION.

The Indian lac insect is of great economic importance to the country. It fetches to its growers and dealers about three crores of rupees annually, and, apart from that, provides the means of livelihood to thousands of the poor classes † of India, especially the aboriginal tribes inhabiting the outskirts of forests and other areas where the host-plants of the lac insect abound.

Of late, the insect has attracted great attention at the hands of all classes of workers. This impetus was partly provided by the Great War, when the

* This paper formed part of a Thesis approved for the degree of Doctor of Science in the Lucknow University.

† Misra (23) writes :—" On an average over 550,000 maunds of shellac, worth about three crores of rupees, are sent out yearly from the port of Calcutta only. The figures of export from the ports of Bombay and Karachi are not available. If these were available it would have been seen that over 700,000 maunds of shellac, worth over four crores of rupees, are sent out of the country. To produce so much shellac, annually at least 140 million lb. of stick-lac must be utilized. If to this be added the internal consumption, which is by no means small, it would be found that the total yearly produce of stick-lac must not be less than 170 to 200 million lb., and if we take the yearly average produce to be 200 lb., at least 280,000 persons must be deriving their subsistence from the industry."

demand for shellac rose high in the market on account of its employment in the manufacture of munitions of war.

The agricultural aspect of this insect industry has been the subject of investigation by Lefroy and Misra, and the latter's Bulletin No. 142 (22) contains much valuable information, and is extremely useful for the purpose for which it is intended. The memoirs of Stebbing (29, 30) and Imms (8) are also valuable treatises on the subject.

Although the lac insect is of such great economic importance to this country, our knowledge of its internal anatomy is very meagre. The present investigation was therefore undertaken by me to make as complete a study as possible of the organization of this important insect. Carter's account (2) of the organography of this insect is, so far as I am aware, the only one of its kind on the subject, and has often been reproduced verbatim by other writers. His description, however, is faulty and incomplete, and needs revision.

The work incorporated in this paper was begun at the Zoological Laboratory of the University of Allahabad, and completed at the Zoological Laboratory of the Lucknow University under the guidance of Professor K. N. Bahl, D.Sc., D.Phil., to whom I am deeply indebted for the keen interest he has all along taken in my work.

I have also to thank the Superintendent of the Horticultural Gardens, Lucknow, for allowing me to inoculate some *Zizyphus jujuba* seedlings with brood-lac and for free access to the nurseries.

This work was done by me during my tenure of the U.P. Government Research Scholarship at the Lucknow University.

2. HISTORICAL AND CRITICAL.

From time immemorial this insect seems to have attracted the attention of naturalists. As early as 250 A.D., Celian (8, 28) mentions that there occurs an insect in India which yields colouring matter. In Ain-i-Akbari (8, 28) we find references to the commercial value of this insect. Besides such scattered references, the earliest scientific account of the lac insect we owe to Kerr (10), who, in 1781, contributed a paper to the 'Philosophical Transactions' of the Royal Society of London. About ten years later Roxburgh (27) gave a detailed account of the insect in the same journal. Later Carter (2) described the external and the internal anatomy of the insect. Since then the external morphology of the insect has been described independently by a number of naturalists, viz., Lefroy (14, 15), Misra (22, 23), Stebbing (29, 30), Imms (8), Duport (6), and recently, more accurately, by Chamberlin (3).

Kerr described the insect under the name of *Coccus lacca*. His account consists of the life-history of the insect together with a brief reference to its food-plants and commercial utility. The account, however, is very faulty, as will appear from the following excerpts :—

(i.) "This insect is described in that state in which it falls from the womb of the parent * in the month of November and December."

(ii.) "When this fluid is all expended, the young insects pierce a hole through the back of their mother * and walk off one by one."

Roxburgh's account of the insect was written from his observations on the insect in Samuleotta †. His description is very similar to Kerr's, consisting, as it does, of an account of the life-history of the insect and a few minor observations on its morphology. Curiously enough he describes only two necks to each utriculus, whereas a closer examination would reveal the presence of three

* The italics are mine.

† Samuleotta is in South India.

distinct protuberances at the aboral end of the insect. The greater part of Roxburgh's account is devoted to Mr. Hellot's process for the extraction of the colouring matter, and the illustrations appended to the text are both poor and inaccurate.

Carter (2) corrected several of the errors of previous workers, and his account of the insect (with special reference to its organography) is about the best available in the literature on the subject. Almost all subsequent observers have relied materially on his account, and have often reproduced it verbatim *. His account, however, is not without faults. He regards the white filaments as the "attenuated extremities of the trachæ," and believes that the "red colouring matter so copiously present inside the insect is contained in the ovary." Furthermore, he thinks that "the larvæ come out through the anal aperture," because he believed the oviduct to open into the rectum. These observations, along with others, I have shown to be erroneous in the following text. Attention to these errors was also called by me in a previous preliminary communication on the subject (24).

Stebbing's memoir (30), though not an anatomical treatise, contains certain references to the internal organization of the insect. The following erroneous statements, amongst others, may be quoted :—

(1) "The lac of commerce originates as an *excretion* † (in the sense of excreta), exuded by the scale *from the anal orifice*, which gradually accumulates round and encloses the insect beneath a shell-like covering."

(2) "The white tufts projecting from these posterior spiracles consist of the *extremities of the trachæ* †, and are covered with a white powder."

(3) "The ovary is filled with a bright red fluid. During the last month of life the eggs are gradually formed within the ovary *from the fluid* †."

(4) "The chief point of interest, therefore, in the interior of the body of the full-grown female are the irregularly massed bundles, without any apparent order, of the white trachæ, *many of whose extremities protrude through the three apertures on the surface* †."

Lastly, Imms and Chatterji (8) give a good account of the external morphology and life-history of the insect, but omit a description of the internal anatomy altogether.

3. MATERIAL AND METHODS.

Both fresh and preserved material were worked upon during the course of the investigation. Preserved material did not prove satisfactory on account of the shrinkage and distortion of the internal organs caused by preservatives. Fresh material was found to be by far the best for dissections. In order, therefore, to ensure a constant supply of material, several young ber trees (*Zizyphus jujuba*) were inoculated with *Laccifer lacca*, the brood of which was obtained from Mirzapore, through the courtesy of Messrs. Rogers Pyat Shellac Co., Ltd. Fresh material was in this way continually available for me.

Dissections were carried out on living material under the Zeiss binocular microscope in a drop of normal salt solution on a slide. I found 4×55 Zeiss a convenient magnification for dissection. On account of the small size of the insect and the large amount of colouring matter present in its interior, the following method was found useful for making good dissections of the various internal organs.

* We find it, for instance, as an appendix to O'Connor's pamphlet on 'Lac Production, its Manufacture and Trade,' and to Watt's 'Dictionary of the Economic Products of India,' vol. ii., and the 'Agricultural Ledger,' No. 9, 1901.

† The italics are mine.

The insects were cut open by a longitudinal slit under the binocular microscope. The two integumentary flaps were then caught hold of by two pairs of fine forceps and the flaps drawn apart to intensify the incision. The interior of the insect was then rinsed with a fine spray of normal salt solution with a pipette. This was repeated several times until no more of the colouring matter came out. The internal organs could then be dissected easily.

Material for sections was embedded in paraffin wax melting at 54–60° C., according to the season of the year, for about forty-five minutes to an hour, sections being cut 6 μ thick.

Various stains were tried, the one giving the best result being Heidenhain's Iron Hæmatoxylin. Most of the sections were counter-stained with Eosin or Orange G.

For studying the openings of the lac glands on the cuticle the following modification of Green's method (7) was found to give excellent results. The specimens, after having been boiled in caustic potash for a short time, were washed with water. An incision was made at the side and the contents removed by a hair-brush with gentle pressure. Specimens were left in water for 24 hours, after which they were again rinsed with two or three changes of water and then transferred to water slightly acidified with acetic acid for 2–3 minutes. They were then again washed with water, and passed through the usual grades of alcohol. In 90 per cent. alcohol they were stained with eosin for 15–30 minutes, transferred to 90 per cent. alcohol to wash off excess of the stain, and then passed into absolute alcohol, after which they were put in carbol-xylol or ether for two minutes and then in xylol or oil of cloves, and finally mounted in Canada balsam. This method brought out the pores beautifully. I have found eosin superior to saurefuchsin, recommended by Green and MacGillivray, and have found treatment with acetic acid and carbol-xylol very helpful in bringing out the pores.

4. EXTERNAL CHARACTERS.

Since it is necessary to be familiar with the external characters of the insect in order to understand the description of the internal anatomy contained in the following pages, I have reproduced below Imms's account of the female lac insect in an abridged and modified form.

The adult female has a dark, crimson colour and is roughly pyriform in shape (Pl. I. fig. 1, A), with the mouth-parts situated at the narrower extremity of the body. Owing to the fact that the larvæ, in the first instance, attach themselves very close together, the individual incrustations become confluent with one another and form thick excrescences partially or completely surrounding the twigs (Pl. I. fig. 1, B). Three apertures are present in each resinous cell (Pl. I. fig. 1), and through them tufts of white filaments protrude. Two of these tufts are relatively long, and are situated in association with the posterior spiracles (correctly speaking, the anterior spiracles), while the third and unpaired tuft consists of much shorter filaments surrounding the anus. The insect measures on an average 5 mm. in length, but different individuals may vary from 4–6 mm.; in maximum diameter they vary from 2.5 to 3.5 mm. The mouth-end of the insect is in contact with the surface of the food-plant. The mouth-parts are of the usual type commonly found among the Coccidæ, being modified to perform the combined function of piercing and sucking. On both sides of the mouth-area are a pair of flattened oral lobes (Pl. I. fig. 3), and the mouth-parts appear to issue from the base of the cleft between these two structures. The mandibles are prolonged into a pair of greatly elongated stylets which are highly retractile, being capable of being drawn inside. The maxillæ are also modified to form stylets.

The labium is modified into a short tubular sheath through which the stylets protrude at its apex. There is, apparently, no trace of labial palps. The labrum and clypeus are broad and flattened, and not prolonged or modified for the purpose of piercing or sucking. A short distance behind the mouth-parts are two small projections measuring .04 mm. in length, each consisting of four minute segments and short terminal setæ (Pl. I. fig. 3). These structures are vestiges or remnants of the larval antennæ. A short distance behind them are a pair of plates, the anterior spiracles (correctly speaking, the posterior spiracles). The anal end (strictly speaking, the aboral end) of the body is provided with three conspicuous processes. The longest of them is known as the anal process (the anal tubercle of Chamberlin), and is surrounded at its apex by a circlet of usually ten setæ (the anal ring setæ of Chamberlin). Outside these setæ there is an incomplete circlet of short flattened spines, together with an additional circlet of shorter setæ. The other two processes are the paired stigmatic processes (the brachia of Chamberlin), each carrying near its base, on the outer aspect, the posterior spiracle (=the anterior spiracle) of its side. Apically each stigmatic process bears a perforated plate (the brachial plate of Chamberlin) from which the long white filaments take their origin. In the centre of the triangular area enclosed by the anal and spiracular processes is a small papilla-like elevation which carries a short chitinous spine (dorsal spine of Chamberlin) tapering to a sharp point. It measures .09 mm. in length, and is one of the most characteristic structures of the family *Lacciferinæ*.

5. INTERNAL ORGANISATION.

(a) *The Integument and the Associated Lac Glands.*

Since the insect owes its importance to the value of the lac resin it secretes, various attempts, speculative and observational, have been made to ascertain the nature of the lac resin and its mode of secretion. It is, therefore, interesting to trace the growth of our modern ideas with regard to these questions. P. Gervais and Van Beneden in 'Zoologie Medicale,' p. 374, 1859, say that lac exudes from certain trees through the punctures which have been made by the female. Similar remarks are also to be met with in such standard works as Muspratt's 'Chemistry,' Wurzt's 'Dictionnaire de chimie,' Johnson's Encyclopædia, and various other works on natural history. In Chambers's Encyclopædia it is stated that the insects "entomb themselves in a mass of matter which oozes from small punctures made in the twigs of the trees." Watt's Dictionary, on the other hand, tells us that "lac is the product of *Coccus lacca*. . . . It appears designed to answer the purpose of affording food for the maggots in a more advanced state." The statement, in so far as it indicates that lac is the product of the insect rather than of the tree, is correct, but the allegation that it provides food for the maggots in the advanced state is a grotesque distortion of facts. The question of the origin of lac has been clearly stated by Stillman (31), who writes thus: "In explanation of these facts we have two alternatives to choose from. First, that the gum is an exudation from the twig, excited by the punctures of the *Coccus*, which flows out, envelops the insects, hardens and forms the gum lac; or second, that the gum is the elaboration of the insect itself." Stillman adduces the following facts in support of his view that the lac is of insect origin:—

(1) "The gum lac is not simple like most vegetable resins, but has a very complex composition. Such a complex substance might be expected to be an animal product rather than of vegetable origin."

(2) "The resin, as far as known, possesses the same general composition and properties independent of the species of plant whence it is derived." (About 90 food plants have so far been recorded from India, but the composition of the resin from different sources is known to vary only within narrow limits, and this is only explainable on the ground of its being an animal product.)

(3) "If the resin were of vegetable origin we should be able to get it without the immediate presence of the insect in a manner comparable to rubber or many other vegetable gums."

It would, therefore, be plain that the theory of the origin of lac-gum as a vegetable product is untenable. The above-mentioned facts conclusively show that the production of lac gum is dependent upon the immediate presence of the insect on the host-plant. This being so, the question as to the nature and location of the lac-producing organs suggests itself.

Comstock (quoted by Imms) termed the stigmatic processes (the brachia of Chamberlin) as "lac-tubes," assuming them to be concerned with the production of lac; but Green (7) did not regard them as such, because he writes that "these processes, together with the caudal extremity, are the only parts from which no lac is produced." According to Stebbing (29, 30), the sap which is sucked up from the host-plant by the insect, after the modification and absorption of some of its constituents, is defecated as its excreta through the anal aperture of the body, which gradually accumulates round and thus encloses the insect. Green (7), in his 'Coccidæ of Ceylon,' remarks that, "with insects that exude such a copious and dense secretion one might expect to find definite areas of specialized glandular character for the purpose," and regrets that no such glands have, so far, been demonstrated.

Chamberlin, in his systematic Monograph of the *Lacciferiine* (3) makes no mention of the presence of any glandular structure concerned with the production of lac. He refers to the distribution of certain clusters of pores in certain regions of the cuticular wall, distributed along certain definite tracts. He has given them differential terms to signify their location, and has also given them considerable prominence on account of having imparted to them a certain amount of taxonomic value. For instance, he refers to the perivaginal pore clusters, the marginal duct clusters, and the ventral duct clusters (Pl. I. fig. 3); but does not mention the presence of any glandular structure associated with these pores or ducts.

It will presently be shown that these pores and duct clusters are the openings of certain discrete structures which I have called lac glands. The lac glands are being described and figured here for the first time.

The integument of the lac insect consists of an outer layer of cuticle, underlying which is the hypodermis, in which cell boundaries are indistinguishable (Pl. III. fig. 1, *Hyp.*). Its cellular character is evident from the presence of numerous prominent nuclei. The cuticle is continuous all over the body of the insect except at the anterior and the posterior spiracular areas. It is also perforated by numerous pores which are the openings of the lac glands lying under it. These pores are arranged in a definite manner. For instance, near the oral end of the insect the pores are congregated into what have been called ventral duct clusters (Pl. I. fig. 3). Similarly, near the aboral end the marginal ducts are arranged along six serpentine areas (Pl. II. fig. 1) engirdling the aboral extremity of the insect; and lastly, on both sides of the anal tubercle there are two oblique rows of perivaginal pore clusters (Pl. I. fig. 3). Along each of these two oblique rows there are 8-12 clusters, each composed of 5-10 pores. Besides these congregated

pore clusters the entire cuticle is perforated by numerous openings which render the appearance of the cuticle somewhat spongy. The pores are rimmed with thickened chitin. But while the ventral pores are flush with the ectal surface, the marginal pores are situated at the apices of tubular evaginations (Pl. II. fig. 1). The prevaginal pores, on the other hand, present a honeycombed appearance (Pl. II. fig. 3).

Underlying the cuticle (Pl. II. fig. 4 and Pl. III. fig. 1) are the lac glands, which are modified hypodermal cells whose function is the elaboration and production of the lac resin. The lac glands are distributed almost all over under the cuticle. From each nucleated glandular cell a delicate duct proceeds to open to the exterior through the cuticle by means of the pores and ducts referred to above. The secretory products of cell metabolism pass out of these channels to the exterior, where, in contact with air and light, these harden into the familiar lac encrustation.

There are two kinds of lac glands. To the first belong those aggregated pleuricellular glands (Pl. III. fig. 2, *Plr.lc.gld.*) which are confined to the area of the perivaginal pore clusters and open to the exterior through these pores. Usually there are 8-12 clusters of such pleuricellular glands at the base of the anal tubercle (Pl. II. fig. 3). They are disposed in two oblique rows, and play an important part in the formation of the resinous cell of the female lac insect*.

The other kind of lac glands are of a unicellular nature with separate slender ducts and prominent nuclei. These again are of two types. There are, for instance, the minute unicellular glands which have slender ducts and small nuclei, and are diffuse in their distribution (Pl. II. fig. 4, *Dff.lc.gld.*), being present all over under the integument except the six serpentine areas of marginal duct clusters and the rows of perivaginal pores. The six serpentine areas are occupied by the second type of lac glands, which, though unicellular, are many times bigger than the preceding ones, and are, further, characterized by the possession of flask-shaped fundi, comparatively wide necks, and prominent nuclei and nucleoli (Pl. II. fig. 4, *Loc.lc.gld.*). Each gland measures .111 to .185 mm., and opens to the exterior through an evaginated chitinous tubercle (Pl. II. fig. 1). These glands are very much localized in their distribution, being confined only to the six serpentine areas of marginal duct clusters (Pl. III. fig. 3, *Srp.ar.*).

(b) *The Gut and its Appendages, with Notes on the Secretion of "Honeydew" and the Presence of Ants.*

The only available account of the gut of the lac insect is that of Carter (2), who describes it as follows:—"The alimentary canal commences with an attenuated *shapeless* † œsophagus at the elongated end of the body which is the oral extremity, and after passing upwards for about two-thirds of the length of the abdominal cavity, where it becomes enlarged and convoluted, turns back to make a single revolution in the course of which it becomes *diminished in calibre* †, and, receiving the *hepatic duct* † at this point, terminates at length in the rectum."

In the above account Carter makes no mention of the peculiar association of the ventriculus with the colon, a character of considerable importance and significance in the Coccidæ. Besides this, he does not refer to the colon-cæcum and the rectal part of the alimentary canal; and, further,

* Mirra, A. B., "On the Post-embryonic Development of the Female Lac Insect, *Laccifer lacca* Kerr," Bull. Ent. Res. Lond. vol. xxi. pt. 4, 1930.

† The italics are mine.

fails to make out the exact mode of opening of the rectum to the exterior. In addition, he does not seem to have noticed the pharynx, which precedes the œsophagus and has salivary glands associated with it. Carter's account of the gut is, therefore, hardly to be regarded as either complete or accurate.

Another account of the gut of the lac insect is that of Duport (8), which is essentially similar to that of Carter. It runs as follows:—"Ce conduit commence par un œsophage atténué, sans forme bien précise, traverse les deux tiers de la partie supérieure de la cavité abdominale où il s'élargit, revient sur lui-même en diminuant de calibre, reçoit le canal hépatique et se termine par le rectum qui aboutit à l'orifice anal."

While the alimentary canal of a number of Coccids has of late been studied by various workers, it is remarkable that their accounts are mostly conflicting, and it may, therefore, be not without interest to review the situation here and to endeavour to rectify the errors, if any, of the previous workers in the light of the results obtained from the study of the alimentary canal of *Laccifer lacca*.

Ramdohr's account (34) of the gut of *Chermes alni* does not contain any description of the different parts of the gut. He simply remarks that it is long, coiled, and transparent. In his description he refers to the expanded stomach and the folds, but is not able to comprehend the nature of these folds. It is evident from the account that he believed these folds to be the foldings of the internal wall of the stomach itself. It is particularly noteworthy to remark that Ramdohr makes no mention of the Malpighian tubes, which must, therefore, be taken to be either absent in the type or unnoticed by him. Moreover, he does not refer to the peculiar mode of attachment of the intestine; and lastly, an account of the rectal part of the gut is altogether wanting in his description, which is very incomplete and, through implications, inaccurate.

The alimentary canal of *Coccus hesperidum* was studied by Leydig (16) and later by Lubbock (17). One is not a little surprised to note the enormous difference between the descriptions of these two authors. Leydig describes it as follows:—"Die Mundhöhle beginnt mit einem langen, dünnen, aus mehreren Schmalen Leisten bestehenden Schnabel und lässt im Innern einige Horngräthen Unterscheiden. Der darauf folgende œsophagus ist kurz und erweitert sich zu einem langlichen Magen, der, indem er sich wieder verengt zum Darmkanal übergeht Letzterer mündet nach mehrfachen Krümmungen am Hinterleibsende mit einem After aus. Während seines Verlaufes gibt er ungefähr im letzten Drittheil zwei Blindsäcke ab, von denen der eine einen einfach gekrümmten Schlauch formt, der frei in die Leibeshöhle ragt, der andere ist knäuelartig zusammen gerollt und steckt nach seinem Abgang vom Darmkanal in einer Blase, die sich bis zum Hautskelet zu verlängern und dort anzuheften scheint. In einiger Entfernung hinter diesen, Blindsäcken mündet Jederseits in den Darm ein Malpighisches Gefäss." In this account, whilst the description of the separate parts is correct, the inter-relationship of the different parts of the gut has been misunderstood by Leydig, who ruptured the intestine in his dissections, and this naturally led to a mis-interpretation of the different parts by him.

Although Leydig refers to a blister-like structure associated with the gut, he was unable to divulge its nature or its mode of exit. This he has confessed in the following statement:—"Die Bedeutung dieses Schlauches, der, wie angegeben, sich an die Innenfläche des Hautskelets zu befestigen scheint, kann ich nicht entziffern."

Lubbock's account (17) of the gut of *Coccus hesperidum* is certainly an

improvement over that of Leydig. Unlike Leydig, Lubbock was able to make complete dissections of the alimentary canal, but he has also erred slightly in interpreting the different parts of the gut. He regards the internal convolutions of the "pear-shaped bag" to be of the nature of an internal gland," and calls the intermediate tract between the so-called "pear-shaped bag" and the rectum as "Ansaminor" (meaning the small intestine). I have shown that these convolutions inside the "pear-shaped bag" (which is the colon) are of the ventriculus, and that the "Ansaminor" is not the part between the so-called pear-shaped bag and the rectum, but the circular loop attached at both ends to the colon.

Witlaczil (34), in his classical studies on the Coccidæ, endeavoured to unravel the nature of the flask-shaped apparatus (the "blase" of Leydig and the "pear-shaped bag" of Lubbock). His description of this part of the gut is as follows:—"Beide sind mit einander verwachsen und beschreiben eine Schraubenlinie, deren Drehungsrichtung in der Mitte sich unkehrt."

To one familiar with the character of the gut in Coccidæ, Witlaczil's description of the "Blistersäcke," or the "flask-shaped apparatus" will appear unintelligible on account of its vagueness, and the figures illustrating his text will not be found either helpful or explanatory. It may, therefore, be surmised that he did not fully comprehend the nature of the structure under discussion.

From the foregoing review it will be seen that the descriptions of the various workers of the digestive tracts of the Coccidæ are mostly conflicting. In recent years several species of scale insects have been studied in the Entomological Laboratory of the Junior Stanford University of California, these species representing several genera such as *Physokermes*, *Ceroputo*, *Icerya*, and *Epidiaspis*. But the accounts are superficial, and apparently no serious attempt appears to have been made to unravel the complexities of the gut and to delineate clearly the inter-relationship of its different parts.

Preceding the œsophagus of the female lac insect is the thick-walled, club-shaped, conspicuously large pharynx (Pl. IV. fig. 2 and Pl. VII. fig. 8) which partly lies within the chitinous framework of the mouth-parts. At the oral end of the pharynx are attached a pair of salivary glands having the form of a bunch of grapes (Pl. IV. fig. 2 and Pl. VII. fig. 8, *Slv.gld.*). Each salivary gland consists of a number of spherical granular lobes with a single narrow duct opening into the pharynx. Aborally the pharynx narrows into the thin-walled elongated œsophagus (Pl. IV. figs. 1 & 2, *Oes.*) which runs up to where it enters the flask-shaped sac (colon-cum-rectum), in the interior of which it describes a few convolutions (Pl. IV. fig. 1 and Pl. VII. fig. 4, *Vent.con.*) and then emerges at the other side of the sac as the recurrent intestine (Pl. IV. fig. 1, *Rec.int.*). The recurrent intestine describes a complete circle, and is attached to the flask-shaped sac (colon-cum-rectum) at both ends. The proximal part of the flask-shaped sac is the colon (Pl. IV. fig. 1, *Coln.*), while its distal part is the rectum (Pl. IV. fig. 1, *Ret.*). The colon gives off a cæcum just close to the point of entrance of the œsophagus into it (Pl. IV. fig. 1, *Coln.cc.*). To the distal limb of the recurrent intestine is attached a pair of brownish-yellow Malpighian tubes (Pl. IV. fig. 1, *Mal.tb.*).

The walls of the pharynx consist of a layer of closely-fitting columnar cells with prominent nuclei. The lumen of the pharynx is circular in transverse sections. The œsophagus (Pl. IV. figs. 1 & 2, *Oes.*) is a narrow tube of uniform diameter throughout its length, and its lumen is circular in transverse sections (Pl. VI.

fig. 3, *Oes.*). The wall of the oesophagus consists of a single layer of columnar epithelial cells with prominent nuclei (Pl. VI. figs. 1 & 3, *Oes.*). The oesophagus is .03 mm. across its widest diameter, with a lumen of .024 mm. The oesophagus is drawn in (Pl. V. fig. 2, *Oes.*) for some distance inside the colon, in the interior of which it forms the much convoluted "blistersäcke" of the German authors and the "internal gland" of Lubbock. The so-called "blistersäcke" is, in fact, the ventriculus, whose walls consist of an epithelial layer of large conical cells, the free ends of which bulge out towards the lumen (Pl. V. figs. 1 & 2, *Vent.con.*). At the base of each cell is a prominent deeply-staining nucleus which is imbedded in a mass of granular protoplasm. The ventriculus is a much-convoluted structure, and is enclosed within the colon (Pl. IV. fig. 1 and Pl. VII. fig. 4, *Vent.con.*). This association of the ventriculus and the colon is a very novel condition, and, as Kuwana (11) has remarked, "this extraordinary condition is common to all the Coccidæ so far studied." I agree with Witlaczil (34) that this association is of a secondary character. Lubbock (17) interprets "the internal convolutions inside the colon" as an internal gland in the case of *Coccus hesperidum*. I have shown these to be convolutions of the ventriculus, and, furthermore, demonstrated that the association of the ventriculus and the colon is not of an intimate nature, since not only could I, on several occasions, remove these convolutions out of the colon by the simple method of teasing with a pair of sharp needles, but my microtome sections also conclusively show that the colon merely surrounds the convolutions of the ventriculus, and that the latter is an independent structure (Pl. V. figs. 1 & 2). Furthermore, in microtome sections it is possible to trace the entrance of the oesophagus into the colon and its continuity with the ventricular convolutions (Pl. V. figs. 1 & 2 and Pl. VI. fig. 3, *Oes.*). The ventriculus, on leaving the colon, is continued as the intestine, which may be said to have proximal and distal limbs, the junction of the latter with the former being marked by the attachment of a pair of Malpighian tubes (Pl. IV. fig. 1, *Mal.tb.*). The wall of the intestine is thrown into a number of folds, usually six, which show further sub-divisions, the result being the formation of crypts in the lumen (Pl. VI. fig. 2). The distal intestine has an internal lining of a chitinous intima. The total length of the recurrent intestine is 5.5 cm. The distal intestine joins the colon close to the point of exit of the proximal limb from it, and on account of this double insertion of the intestine some authors have given it the name of "recurrent intestine." The colon (Pl. IV. fig. 1, *Coln.*) is a thin-walled structure, and gradually passes into the rectum. Its wall consists of a single layer of conical cells (Pl. VI. fig. 3, *Coln.wl.*) with prominent nuclei. It is rather difficult to distinguish the distal part of the colon from the rectum in sections, since the structure of their walls is identical (Pl. V. figs. 1 & 2, *Coln.wl.*). The rectum, which is the last part of the gut, also has a thin wall like that of the colon. Its lumen is also lined with chitinous intima (Pl. VII. fig. 1, *Rct.wl.*), which is continuous with the outer cuticular covering of the body of the insect. The chitinous intima has a tuberculated appearance, and is probably supported by a flattened epithelium in which nuclei are indistinguishable. The ridges gradually fade away as the anus is approached.

The origin of a large pair of Malpighian tubes marks the junction of the proximal and distal intestines. The Malpighian tubes are of uniform width throughout, being never more than two cells thick (Pl. IV. fig. 1 and Pl. VIII. figs. 3-6) in surface view. The two rows of cells alternate with each other and are enclosed within a thin covering. The cells are laden with yellow or brown excretory matter (Pl. VIII. figs. 3-6, *Exc.gr.*) and possess prominent

comma-like nuclei. On account of the distention of the cells with excretory matter, the Malpighian tubes look beaded in appearance (Pl. IV. fig. 1 and Pl. VIII. figs. 3-6).

Honeydew and its Secretion.

It has long been known that the Coccidæ secrete a fluid known as *honeydew*. Targioni-Tozzetti in his Memoir (32) does not throw any light on the mode of its secretion or the organ concerned with it. Maskell (20) while studying the pupal stages of the female of *Ctenochiton elaeocarp*i and *Cælostoma zelandicus* noticed the sudden extrusion of an organ between the two dorsal lobes and the ejection of a drop of honeydew. Kuwana (12) closely watched the process of honeydew secretion in *Wajaricoccus corpulentus*, during the winter of 1916, while the larvæ were most actively secreting the substance, but he did not notice the extrusion of any cylindrical tube such as described by Maskell; and Kuwana (12) and Newstead (25) have emphatically repudiated Maskell's observations, and believe that the honeydew is exuded from the anal opening.

In common with other Coccidæ, *Laccifer* also produces large quantities of honeydew, so much so that the low shrubs and the plant seedlings growing under lac-bearing trees and receiving honeydew from them become densely black on account of a fungoid growth * upon them. Imms (8) in this connection says:—"From soon after fixation onwards *Tachardia luca* (= *Laccifer luca*) secretes, apparently through the anus, considerable quantities of honeydew analogous to that produced by Aphids"; and Misra (22) also makes a similar statement:—"At this time a copious amount of sugary liquid, technically known as the honeydew, is excreted; and this, falling on the leaves, branches, and the ground below, develops a black fungus."

It is a matter of common observation that honeydew is expelled from the anal opening of the female lac insect. It is not uncommon to observe the anal tubercle being shot out of the opening in the resinous vault and a drop of honeydew expelled and arrested by the anal ring of setæ. It seems to me that the honeydew is a mixture of the excreta of the lac insect plus some sugary constituents of the plant-sap mixed up in the manner indicated below.

I have already shown that the wall of the ventriculus consists of a single layer of conical cells with prominent nuclei. The lumen of the colon is separated from that of the ventriculus only by the thin unicellular wall of the latter (Pl. V. figs. 1 & 2). When some excrementitious liquid is present in the colon and the ventriculus is also full of plant-sap, it is likely that an osmotic exchange between the two liquids, separated by a semi-permeable membrane, takes place. The sugary constituents of the plant-sap will, on passing out of the interior of the ventriculus and mixing with the excreta, which is essentially liquid in the colon, impart to it a sugary taste. This mixture, when defecated, will, by virtue of its sweet flavour, attract ants.

Honeydew and the Presence of Ants

Ants are found in association with colonies of Coccids. The popular belief is that this association is of a symbiotic nature, the ants being nourished by the honeydew produced by these insects, in return for which the ants protect

* Imms got this fungoid growth identified by the Imperial Economic Mycologist, India, and it was declared to belong to the genera *Fumago* and *Capnodium*. Kuwana (12) has also reported fungoid growth of *Meliola* sp. and *Capnodium citri* on the honeydew of *Wajaricoccus* and *Icerya* respectively.

them from external enemies. In this way, it is conjectured, they have struck up a symbiotic relationship to the mutual advantage of both. The occurrence of ants in such colonies of Coccids and other allied insects is so common and widespread that such ants have come to be known as "aphidicolous and coccidicolous ants," and it is believed that the instincts of both the insects have specially been adapted and modified to this end. Numerous writers have indicated the way in which the ants draw their sustenance. It is said that the ants go even so far as to tickle the insects to make them secrete more fluid by stroking their antennæ against the caudal extremity of the body of these insects. When this is done these insects are said to expel more of the fluid to satiate the thirst of the ants. But there is a serious implication in this observation which has escaped criticism. It implies that the Aphids, Coccids, and other allied insects are capable of expelling an enormous quantity of this fluid at all hours and at all times. I have already outlined the method by which this fluid is probably produced in *Laccifer*, and it will, therefore, be evident that this fluid is capable of being expelled in a limited quantity only, and that, too, only periodically. Constant tapping will not yield any supply of it, because the honeydew is dependent for its elaboration and production upon a vital process, and is liable to be expelled only when some of it has got accumulated in the colon. If the ants happen to tickle the insect at this moment, the fluid is most likely to be expelled. The statement, therefore, that enormous quantities of it are expelled, and that the ants make them secrete more of the fluid by constantly tapping them, does not seem to be based upon sufficient observation. Maskell's (20) report that there are no ants in New Zealand, although honeydew-secreting Coccids occur there, is a weighty statement in this connection. It therefore follows that the honeydew is produced primarily not for the ants, or, for the matter of that, for any other insect, but is due to a vital process which will go on uninterruptedly irrespective of the presence or absence of the ants and their solicitations. I am further supported in this assertion by Proudfoot who, in a letter to Romanes (26), wrote that "the aphids showered down their excretions independently of the ants' solicitations," while at other times he noticed that ants would approach an aphid without getting anything.

From the same letter it is evident that Darwin had attempted to induce the aphids to yield their secretions, but failed even after repeated attempts. Romanes writes that Darwin also thought that the aphids are bound to get rid of their secretion in any case, and, therefore, that they do not excrete solely for the benefit of the ants.

During the course of my study I have on numerous occasions observed the secretion of honeydew drops from the anus of the female lac insect while a twig bearing lac encrustations was being examined by me under the microscope. This goes a long way to show that the honeydew is not secreted for ants or, for the matter of that, for the benefit of any other insect.

(c) *Tracheation.*

At the aboral end of the insect there are three tubular protuberances (Pl. I. figs. 1 A & 3) which are, roughly speaking, situated at the apices of an isosceles triangle. One of these protuberances, the anal tubercle, is longer than the other two, which are commonly known as the "stigmatic tubes" (the brachia of Chamberlin), on account of their association with the spiracular openings. The so-called stigmatic tube consists of the brachium (Pl. I. fig. 3), surmounted at the apex with a sieve-like brachial plate (Pl. I. fig. 3). The brachia are grooved at their outer margins, and in these grooves the anterior

spiracular openings are located. The brachial plates are lids surmounting the brachia, and are perforated in a sieve-like manner. According to Chamberlin (3) the brachial plates form one of the most characteristic features of the sub-family *Lacciferinae*. Brachial plates in *Laccifer* (= *Tachardia*) are subcircular, with shallow depressions which, in their own turn, bear smaller depressions or dimples. The brachial plates have a collar of thickened chitin.

Only two pairs of spiracular openings are present in *Laccifer* (= *Tachardia*), the anterior pair being larger than the posterior one. The number four seems to be somewhat common in most Coccidæ, because *Coccus* (16), *Icerya* (9), and several other genera have all been reported to possess the same number of spiracular openings. The anterior pair of spiracles in the female lac insect is borne by the corresponding brachium of each side. In *Laccifer* the anterior spiracles and the corresponding brachia are firmly united, forming really a single continuous chimney-like structure. The anterior spiracular opening is situated in a groove on the outer margin of the brachium. The opening leads into a chamber, the "caværa" of MacGillivray (Pl. VII. fig. 3, *Cav.*). Witlaczil (34) also reports the presence of such a chamber in *Chermes*, because he says:—"Jeder stigma führt unmittelbar in eine 'Tracheen-blase.'" From the base of this chamber the main tracheal trunk arises. It soon divides into several branches which in their own turn divide and sub-divide, thereby giving rise to a bushy tuft of tracheæ. A small slip of muscle is found attached to the spiracularia of the caværa in the corresponding brachia. Witlaczil also records the presence of such a muscle in *Chermes*, and says:—"An derseits findet man an der nach innen gewendeten Längsseite des Stigmas einen aus zahlreichen Fasern bestehenden breiten und manchmal wie in zwei Hälften zerfallenen Muskel angesetzt, dessen anderes breiteres Ende sich in einem Bogen und weit an der Hypodermis fest heftet. Nach ihrer ganzen Bildung kann diese Vorrichtung nur dazu dienen, das Stigma, welches durch die Elasticität seiner chitin-wandungen zusammen-gepresst wird, zu öffnen." The tracheæ ramify all over the interior of the insect body, and can easily be followed on account of their glistening appearance due to the presence of air inside them. Bordering the peritreme or the rim are numerous pores.

Through the sieve-like brachial plates numerous waxy threads are given off. These waxy threads were misunderstood by Carter (2) to be "the attenuated extremities of the tracheæ." Stebbing (29, 30) also shared this opinion, because he wrote that "the white tufts projecting from these posterior spiracles (*i. e.*, the anterior spiracles, correctly speaking) consist of the extremities of the trachea, and are covered with a white powder"; and further, that "the chief point of interest in the interior of the body of the full-grown female are the irregularly massed bundles, without any apparent order, of the white tracheæ, many of whose extremities protrude through the three apertures on the surface." Duport (6) also held similar views, because he writes:—"Ce dernier, qui est le plus grand, correspond à l'ouverture anale du corps de la femelle et les deux autres aux orifices respiratoires et c'est de ces trois orifices qui partent mites de la trachee-artère et qui assurent l'arrivée de l'air au corps de l'insecte à travers la couche de résine"; and further on: "trachées . . . et émettent des prolongements passant par les trois orifices due corps de la femelle et se terminant par les filaments blanc qui se remarquent à la surface du stick-lac." Imms (8) rectified the erroneous statements of Carter, Stebbing, and Duport. He pointed out, for the first time, that the filaments were of a waxy character, and not prolongations of the internal tracheæ. I desire to confirm Imms's statement, and to reject Carter, Stebbing, and Duport's views. Imms, however, did not demonstrate the presence of wax glands concerned with the production of these waxy threads.

The posterior spiracles are not so prominent as the anterior ones, and are found lying in the vicinity of the oral end, borne upon chitinous plates (Pl. I. fig. 3). They are constructed on the same structural plan as the anterior spiracles. Pores are also present on their borders. From the opening of the posterior spiracles tracheæ are also given off, which divide and sub-divide, the ultimate branches ramifying into the interior of the body-cavity. The tracheæ in association with the posterior spiracles are, however, not so numerous as those belonging to the anterior spiracles.

Although Imms suspected the white filaments given off from the aboral extremity of the insect to be of a waxy consistency, and repudiated Stebbing's views, yet he did not demonstrate either the source of their origin or formation. I have found definite wax glands under the brachial plates which pour out their secretion through the "nuclear ducts," in passing through which it is moulded into the filamentous form. The structure and distribution of these wax glands has been dealt with elsewhere in the following text.

(d) *Myology.*

Carter (2), in his description of the internal anatomy of the lac insect, makes no mention of its myology. It therefore seems to me that it escaped his attention. The myology of the lac insect is peculiarly interesting inasmuch as it does not show the usual type of musculature met with in the generalized Coccidæ. This seems to be correlated with its fixed habit of life, the insect being enclosed in a resinous cell with locomotory movements reduced to nil. As it is, however, the myology of the lac insect is excellently adapted to its requirements, limited as they are.

Only three principal fascia or bundles of muscles are possessed by the female lac insect. Two of these are attached near the mouth-parts on the one hand, and on the other they are inserted in the interspaces between the anal tubercle and the brachia of their corresponding sides (Pl. VIII. fig. 7, *Trg.st.mus.*). Each of these is composed of five or six muscular slips, and disposed on both sides of the anal tubercle. The remaining fascium is attached at the oral end near the cesophagus on the one hand, and on the other extends into the anal tubercle, which it muscularizes (Pl. VIII. fig. 7, *Lng.st.mus.*). Besides these extreme points of insertion, this fascium is attached to the integument at four or five points in its course (Pl. VIII. fig. 1, *Alm.*), and thins out as we trace it from the anal tubercle to the oral end (Pl. VIII. fig. 7).

In the adult female it is not possible to evaluate the correct morphological value of these muscles on account of the obliteration of surface limitations and the abnormal events of the post-embryonic development of the female lac insect. But my studies on the post-embryonic development of the female lac insect have shown that the muscles, which are inserted near the mouth-parts on the one hand and the space between the anal tubercle and brachia, represent the tergo-sternal muscles; whilst the other, which runs from the oral end to the anal tubercle, is, truly speaking, the longitudinal sternal muscle. It is on this account that it bears marks of four or five attachments (Pl. VIII. fig. 1, *Alm.*). It would, therefore, be proper to denominate these muscles as such. The function of all these three bands of muscles is intimately correlated with the suction of sap by the female lac insect from its host-plant. Besides these principal muscular bands, slips of muscles are also found in association with the spiracularia of the caværa in the two brachia. My observations on the post-embryonic development of the female lac insect have shown that these slips of muscles are derived from one or two longitudinal tergal muscles which come within the zone of influence

of the developing brachia. Most of the longitudinal tergal muscles are disorganized on account of the development of the dorsal spine, but just a few survive inside the anal tubercle. Similarly, only a few tergo-sternals survive in the interior of the anal tubercle. It will therefore be seen that the anal tubercle is richly muscularized (Pl. VIII. fig. 7 and Pl. X. figs. 4-10), and necessarily so. The contraction of these muscles would bring pressure to bear upon the colon-cum-rectum part of the gut, thereby helping in the ejection of any liquid excrement that may have accumulated in its interior. The elasticity of the muscles, subsequently coming into play, would restore the anal tubercle and the muscles to their normal state.

The muscles constituting the muscular bands referred to above are of the striated kind. In the case of *Coccus hesperidum*, Leydig (16) made the following remarks:—"Die noch etwelche Locomotion vornehmen, sind die primitiv cylinder deutlich quergestreifter Natur, an älteren Individuen aber, die kaum mehr sich fortbewegen, zeigen sich die Muskelcylinder wie verkümmert und von Querstreifung ist vielen fallen nichts weiter sichtbar." This statement does not, however, apply in the case of the adult female lac insect, in which the muscles are of the striated nature, although the insect is of a fixed habit and performs no wandering movements on account of its permanent enclosure in a resinous cell for life. However, in the larval stages movements are performed by it and striated muscles are, therefore, possessed by them. When the larva changes into the adult these striated muscles are inherited as such.

(e) *The Vascular System.*

A vascular system in the Coccidæ has not, so far as I am aware, hitherto been reported. I have also not been able to make out a dorsal vessel or any structure comparable to it in the female lac insect. All traces of a dorsal vessel seem to have been lost, and, as Johnston (9) has remarked, "the blood probably circulates through the open body cavity." Kuwana (11), Childs (5), and Moulton* also deny the existence of such a vessel in *Gossyperia ulmi*, *Epidiaspis piricola*, and *Physokermes insignicola* respectively. The scale insects as a whole seem to be lacking in anything that may be called a circulatory system, for no trace of a pulsatile vessel is found that would indicate the presence of any such system. Even the sections of the early larval and pupal stages did not show any structure comparable to the pulsatile vessel of generalized insects, and this organ may, therefore, be taken to be completely absent. Several series of sections of the larvæ and the pupæ were prepared by me to study this feature, but no trace of it was found.

(f) *Nervous System.*

The nervous system is represented by two separate ganglia, one of which is situated in close proximity to the colon-cum-rectum portion of the gut at the base of the anal tubercle, whilst the other lies floating in the body-cavity, and may be found lying closely applied to the Malpighian tubes. In outline the former of these (Pl. VII. fig. 9), which I propose to call the rectal ganglion (*Rct.gg.*), is roughly triangular, and gives off several stout nerves which in their own turn subdivide into finer nervures innervating the internal organs. The other ganglion is oval in shape (Pl. VIII. fig. 2, *Crb.gg.*), and is easily distinguishable from the cells of the Malpighian tubes on account of its glistening white appearance and the absence of dirty brown excretory granules from its

* Moulton, D., "The Monterey Pine Scale, *Physokermes insignicola* (Craw.)," Proc. Daven. Acad. Sci. Iowa, vol. xii. June 1907, pp. 1-26.

interior. Two slender nerve-like filaments can also be seen issuing out of this ganglionic mass. The true morphological value of these ganglia baffled me until the completion of my studies on the post-embryonic development of the female, which enabled me to ascertain their true value. The post-embryonic development of the female lac insect shows sweeping upheavals in structure, and since the details of this process have been dealt with in a separate paper by me, suffice it, for the present, to point out that the nervous system of the female producing pupa is not able to keep pace with the enormous post-gestational growth of the imago, and the strain on the nervous system is so great that it gives way at its weak point, the position of the connectives, so that the cerebral and the thoracico-abdominal ganglia become disconnected. It will therefore be evident that the rectal ganglion of the adult female lac insect represents the thoracico-abdominal ganglion, whilst the one lying close to the Malpighian tubes is, in fact, the cerebral ganglion of the female producing pupa. This interpretation of the true morphological value of these ganglia is based on the results of the study of the post-embryonic development of the female lac insect*.

(g) *Female Reproductive System.*

The ovary of the female lac insect is a voluminous organ filling up nearly the whole of its interior during the post-gestational period of growth and development. In the earlier stages it is an arboreal structure (Pl. IX. fig. 1, *Ovr.*) branched dichotomously, each branch bearing a number of diverticula or ovarioles in which the embryos subsequently undergo development. The oviducts of opposite sides unite to form a median structure, the uterus (Pl. IX. fig. 1, *Ut.*). The distal portion of the uterus functions as the vagina (Pl. IX. fig. 1, *Vgn.*) which opens to the exterior by an opening, the female genital opening, on one side of the anal tubercle (Pl. IX. fig. 1, *Fem.gn.opn.*). A little above the point of junction of the oviducts is attached the receptaculum seminis (Pl. IX. fig. 1, *Spt.*).

In the early stages the ovarioles, which later function as embryo-sacs, are clear and granular. Gradually these diverticula enlarge and become the most conspicuous structures of an advanced gravid female. Later, each becomes constricted into a small lid chamber and a large basal chamber. In the lid chamber numerous cells with distinct nuclei can be recognized. The developing oocyte is also recognizable, and some time later the constriction disappears and the developing embryo comes to occupy both the chambers. Stebbing (29, 30) maintains "that during the last month of life the eggs are gradually formed within the ovary from the red fluid contained inside the pouches." Evidently this view is erroneous. The embryos develop from the fertilized ova as in all other insects, and not "from the red fluid contained in the pouches." I have seen distinct nutritive cells with prominent nuclei in the lid chamber and the oocyte also. The scientific truth embodied by the well-known saying, "Omnis cellula a cellula," precludes the possibility of their arising out of the red fluid as Stebbing makes it out to be. This error was detected by Imms also (8), and rectified by him in his memoir. I agree with Imms that this statement is unfounded and erroneous.

The occurrence of hundreds of diverticula in the female lac insect is a remarkable feature of its anatomy, and is due to its viviparity. An analogous case is met with in *Scorpio fulvipes* described by Laurie (18). Among Coccids, Johnston (9) and Kuwana (11) have reported the presence of such diverticula in *Icerya purchasi* and *Gossyparia ulmi*.

* Misra, A. B., "On the Post-embryonic Development of the Female Lac Insect, *Laccifer lacca* Kerr," Bull. Ent. Res. Lond. vol. xxi, pt. 4, 1930.

The receptaculum seminis, which has already been referred to by me, was not mentioned by Carter (2). It is a stalked structure with a rounded chamber at its apex. It opens (Pl. IX. fig. 1, *Spt.*) into the uterus a short distance behind the union of the two oviducts. Evidently it is intended for the storage of spermatozoa received from the male during copulation. On several occasions I have teased these out, and invariably found them full of spermatozoa (Pl. VII. fig. 6, *Spz.*). Microtome sections also confirmed this observation (Pl. X. fig. 1). Each spermatozoon (Pl. VII. fig. 6, *Spz.*) is a long, tapering, filamentous structure, with a distinct head and a body. When examined under 1/12 oil-immersion lens, the head of the spermatozoon appears twisted like a screw. The total linear measurement of a spermatozoon is .48 mm., of which the head occupies .015 mm.

The wall of the ovary consists of a thin cellular layer (Pl. IX. fig. 2). The cell boundaries are distinct and the nuclei are prominent. The oviducts are prolongations of the ovarian wall, and have the same essential structure as the latter. The wall of the uterus (Pl. IX. fig. 5) consists of an internal layer of columnar epithelium resting externally on a layer of circular muscles, external to which are the longitudinal muscle fibres. The vagina (Pl. X. fig. 2) has almost the same structure as the uterus, but differs from it in having the cells of the columnar epithelium more elongated and more closely packed together, due to its being thrown into folds and its lumen being lined with cuticle. The receptaculum seminis has a structure resembling that of the uterus, except for the fact that its nuclei are larger, and no cell boundaries are distinguishable in its internal epithelial layer (Pl. IX. fig. 5).

Carter (2) was not able to determine whether the oviducts opened independently to the exterior or through the rectum. He believed the oviducts to open ultimately into the rectum, but this is far from being the case. I have already indicated (24) that the vaginal (Pl. VII. fig. 7) tube partially traverses the anal tubercle alongside the rectum, and opens to the exterior on one side quite independently of it. Microtome sections of the anal tubercle show that the rectum and the vaginal tube are quite independent of each other throughout their course. The rectum opens apically, whilst the vaginal tube opens laterally at the side (Pl. X. figs. 4-10).

Greatly divergent opinions are held about the mode of emergence of the larvæ. Carter (2), as has already been pointed out, guessed the oviducts to open into the rectum, and consequently entertained the belief that "the larvæ come out through the anal aperture." Stebbing (29, 30) believed the larvæ to "issue either through the anal orifice or through the rupture of the skin." In addition to these two methods, Imms (8) considered the spiracular openings also to be channels of exit for the larvæ, because he remarks that "they make their exit chiefly through the anal orifice, but a certain number also find their way out through the spiracular apertures." I have watched with considerable interest the emergence of the larvæ, and desire to point out that none of the above methods are warranted by critical observations.

It has been shown by me (24) that the oviducts open independently of the rectum, and hence there is no possibility of the young ones coming out through the rectum. Carter believed the oviducts to open into the rectum, and hence conjectured the young ones to issue out of the anal aperture. Furthermore, there is no possibility of the exit of the larvæ through the spiracles as proposed by Imms (8). From my description of the tracheal system it will be clear that in association with the anterior and posterior spiracles there are bushy tufts of tracheæ, and that the structure of the spiracles is much too complicated to permit the larvæ to find their way out through them. As a matter of fact the tracheæ form such a bushy mass that the larvæ will be entangled in them

and never be able to find their way out. Stebbing's (30) statement that the young ones issue out by rupturing the skin of the mother is equally unfounded. I have on numerous occasions removed the resinous cell to expose the females from which larvæ were issuing out to see if the skin was in a ruptured condition, and have not found it so. The normal mode of larval emergence is through the female genital opening on the side of the anal tubercle (24).

When the embryos are fully formed and the period of their emergence draws near, they leave the diverticula, travel up the oviducts and the uterus, and escape *via* the female genital opening, which is situated on one side of the anal tubercle. Dissections of the female during the seasons of emergence of the larvæ have also shown the embryos in all stages of ascent up the oviduct, the uterus, and the vaginal tube. Microtome sections also confirm the above observations.

6. WAX GLANDS, THEIR STRUCTURE AND DISTRIBUTION.

It has already been indicated by me that white waxy filaments are given out at three points on the resinous cell of each female lac insect. These correspond, in respect of position, to the anal tubercle and the brachial protuberances at the aboral end of the insect. On examination it is seen that the filaments issue out of the dimples on the brachial plates surmounting the brachia and from the anacerores on the anal ring at the summit of the anal tubercle. In sections it is found that a large number of glands lie under each of the above-mentioned parts. The component wax glands have a narrow neck and a comparatively elongated fundus. Numerous nuclei are distinguishable in them, but the cell boundaries, though distinguishable in the neck region, are not well defined in the fundus portion of the glands. The brachial wax glands pour out their secretions through the "nuclear ducts," which open by the dimples on the brachial plate, whilst the circumanal wax glands pour out their secretions through the anacerores on the anal ring. So far as it has been possible for me to determine their form and structure, it seems that the wax glands of the female lac insect resemble those described by Visart (33) and Matheson (21). But I do not share Matheson's view that "the secretion of these cells is poured through these pores and the cylinder forms the mould in which the thread takes shape." On account of their pleuricellular nature these wax glands are different from those of *Phromnia (Flata) marginella* described by Bugnion and Popoff (1).

7. DORSAL SPINE AND ITS ALLEGED FUNCTIONS.

Although it has been known for a long time that the female lac insect produces considerable quantities of honeydew, yet quite contradictory views have been held by different authors regarding its nature and the organ concerned with its production. Green (7) first assigned a glandular function to the dorsal spine of the female lac insect, and believed the honeydew to be secreted by it. In support of this assertion he demonstrated the presence of a gland in association with the dorsal spine of *Metatarchardia* (= *Tachardia*) *conchiferata*. He does not, however, seem to be quite convinced of the glandular function of the dorsal spine, notwithstanding his demonstration of a so-called "gland," since he writes thus:—"Its point is not sharp enough to allow of its employment as a sting, nor is there any indication of the special muscles that would be necessary for its efficacy in such a capacity. Moreover, its position, boxed up within the hard resinous cell, would seem to preclude any such use. Its absence in all but the adult stage might suggest some association with the

sexual function, but it is difficult to conceive why this particular genus should have acquired a peculiar accessory sexual organ." It will therefore be seen that to a single structure Green has attributed no fewer than three different functions contradictory to one another, and there is no positive evidence in support of any of them.

In order that this structure might function as a sexual guide, it is necessary that it should extend beyond the resinous cell, so that it might be visible to the male lac insects in their quest for the females. But the fact that the anal spine does not project outside the resinous vault precludes the possibility of its functioning as such. Further, the dorsal spine is situated in the centre of the triangular area enclosed by the three protuberances at the aboral end, and is equidistant from all of them. It is difficult to imagine how it can function as a sexual guide when it does not point towards the female genital opening.

Again, Green has ascribed a secretory function to this structure, and has mentioned the occurrence of a gland in connection with it. It has been remarked by both Green (7) and Chamberlin (3) that "the plates and folds that appear in association with the spine seem to be of a chitinous nature." I agree with Green in his description of the dorsal spine, but think him to be mistaken in his views about the "gland in connection with the dorsal spine," for a chitinous structure is at best not a living one, and hence incapable of discharging a glandular function. Further, the dorsal spine does not project, but is embedded in the resinous vault like "a nail fixed into a plank which does not reach the other side of the wood." In this position its glandular secretion, if any, is not likely to reach the exterior and be of use to the insect.

Green has also assigned to this structure the function of a sting. A sting in the case of a colony-forming insect like this, which passes its whole lifetime inside a thick resinous cell, does not seem to be necessary. The chances of external injury to the female lac insect are nil on account of its enclosure in a resinous cell, and the acquirement of a sting by this insect would, therefore, be both extravagant and superfluous. Lastly, the fact that the dorsal spine does not project from the resinous vault precludes the possibility of its even functioning as such.

Mahdihassan (19) regards the spine as discharging a mechanical function. The following considerations will show that Mahdihassan's observations are of one who is anxious "to come to some definite idea with regard to the rôle the spine plays in the life of the lac insects," and obviously he approached the subject preoccupied. Mahdihassan's contention is that the process serves to fix the insect to the ceiling. "The spine acts like a nail," he says, "and by being embedded in the resinous vault supports the entire weight of the insect." In the case of an insect surrounded on all sides by a hard, resinous cell, and attached orally (and in most cases laterally also to the contiguous cells) to the twig of the host-plant, such a utility of the spinoid process seems to me to be more imaginary than real. The lac insect is firmly attached to the surface of the host-plant at its oral end by the rostrum being sunk into the plant-tissues, and is rigidly enclosed in a thick resinous cell all round. In places of thick encrustation the cells are closely and firmly packed up, and must thereby be giving additional rigidity and support to one another.

In cases of good encrustation the resinous crust is very thick and hard, it being even difficult to cut it with a big knife. In certain samples of lac the resinous deposit is half an inch thick, and therefore Mahdihassan's statement does not seem to hold good. While it is clear that not one of the functions hitherto assigned to the structure is the probable one, it is difficult to suggest

anything further about it, since no homologous or analogous structure of the kind is met with in the allied Coccidæ. Green was more correct when he remarked that "the function of this organ is a puzzle."

8. THE RÔLE OF ANTS IN LAC CULTIVATION.

A somewhat interesting discussion has of late arisen with regard to the rôle of ants in lac cultivation. The experience of the cultivators and growers is on the side of regarding ants as harmful to a successful cultivation of lac. On the other hand scientific observers seem to be divided in their opinion on this point. Lefroy (14, 15), Imms (8), and Mahdihassan (19) hold that the ants are not injurious to lac cultivation, while Stebbing (29, 30), Duport (6), and Misra (22) regard them as such. Brief references to the opinions of these experts may not be out of place here :—

(1) LEFROY (14, 15) :—

"Ants are not destructive to Coccids as is so frequently believed. but visit them to obtain their sweet excretion."

(2) IMMS (8) :—

"... the ants do not seem to do any appreciable harm to the lac. . . . Several writers have emphasized the injuries incurred by the presence of ants, but their statements do not appear to have been based on sufficient observation."

(3) MAHDIHASSAN (19) :—

"... the lac insect secretes sugars which invite ants. Ants in return for their food, protect the lac insect from its enemies."

Against this we have

(i.) STEBBING (30) :—

From a perusal of the author's memoir it will be seen that he regards the white threads issuing out of the three processes to be continuations of the tracheæ, and he seems to think that the ants, while running up and down the tree, break off some of these continuations of the tracheæ and the insects die of asphyxia in consequence.

(ii.) DUPORT (6) also regards ants as injurious, and suggests methods of control. In agreement with Stebbing, he also regards the white threads as continuations of the tracheæ, because he says :—"Trachées . . . et émettent des prolongements passant par le trois orifices du corps de la femelle et se terminant par les filaments blancs qui se remarquent à la surface du stick lac."

(iii.) MISRA (22) also regards ants as injurious to a successful cultivation of lac. He explains the injury to arise in the following manner :—"When the ants walk over the female cells, the waxy threads that come out of the anal tube, as well as the chitinous shields over the two posterior stigmata, stick to their legs and are unconsciously broken off. At times the ants have been observed to bite off the threads with their mandibles and to lay the bits aside, but close to the stigmata. The possibility is that parts of these threads, as well as the cretaceous wax lying at the mouth of the spiracular opening, become consolidated into a compact mass, thus blocking the spiracular opening and bringing about the death of the

females within the resinous cells through asphyxiation. If the resinous cells enclosing females be examined closely, the anal tube as well, as the two posterior spiracular shields over the two posterior stigmata, will be found to lie loosely within holes on the resinous cells. By the frequent passing of the ants such holes become blocked with portions of cretaceous threads, unconsciously broken off by the ants in their attempts to lick the honeydew that asphyxiation, and subsequent dying of the females takes place."

Misra and Stebbing believe the injury to arise from mechanical damage to the so-called tracheal prolongations. The fact that these filaments have been regarded by these two authors as prolongations of the tracheæ is, as I have shown elsewhere, erroneous, and is the basis of their views. I have shown these filaments to be produced by wax glands, which are situated under the anal ring and the brachial plates, and consequently the lac insect cannot die of asphyxia as suggested by Stebbing (30), Duport (6), and Misra (22). I have reared lac insects for my work at the Horticultural Gardens, Lucknow, and in Thakurganj Gardens, and although hundreds of ants have always been found on the trees, yet no damage to the lac insects has ever been noticed by me. Recently I reared lac insects in Badshahbagh, near the Zoological Laboratory, and notwithstanding the fact that hundreds of ants were upon the trees, the lac insects flourished. It is only when the occurrence of lepidopterous and hymenopterous predators and parasites coincides with the presence of ants, as happens almost invariably, that the ants are blamed for the injury which is, in reality, due to other agents. The theory that ants preyed upon the Lac insect has recently been disproved at the Namkum Lac Research Institute also.

9. THE DEATH OF THE FEMALE LAC INSECT.

A remarkable fact about the female lac insect is its death after larval emergence. Previous workers supposed the larvæ to emerge through a rupture of the body-wall of the mother, and consequently the death of the mother was regarded as inevitable. But with the revision of our knowledge on this point, the reason of the death of the mother appeared obscure. During the course of my studies on the post-embryonic development of the female, some facts came under my observation which seem to account for the death of the female.

If the female lac insect be closely watched, it will be seen that the gravid female is several times the size of the young one. This growth in size is accompanied by changes in internal anatomy. The large, brownish-yellow, beaded Malpighian tubes form a conspicuous feature of its anatomy. The size of the Malpighian tubes of the gravid female is six times the size of those of the young one. The Malpighian tubes of the gravid female grow not only in length, but also radially. The Malpighian tubes of the young female, before the emergence of the males, are made up of two rows of closely-fitting granular cells with prominent nuclei (Pl. VIII. fig. 3). The excretory cells at this stage are clear, but in later stages these cells may be seen to contain some dirty granules of excretory matter (Pl. VIII. fig. 4). During the post-gestational period of the female the cells of the Malpighian tubes become more and more laden with excretory granules—so much so that the cells ultimately become distended with them and assume a dirty-yellow colour, and the Malpighian tubes look like a string of round beads (Pl. VIII. fig. 6). At this stage it is no longer possible to make out the nuclei, and if, perchance, the Malpighian tube is ruptured at any point, a lot of brownish-yellow matter at once comes out. Further changes consist in the distension of the cells

to an extreme degree. The reason of the death of the female lac insect, therefore appears to me to be due to the incapacity of the Malpighian tubes to extract any further quantity of waste matter from the perivisceral fluid on account of the utmost distension of its cells. Similar instances of death from auto-intoxication are known among the Ascidians and the Anurida.

10. SUMMARY.

1. The integument of the lac insect consists of an external layer of cuticle, underlying which there is the syncytial hypodermis, many of whose cells are modified into lac glands which secrete the resin of commerce.

2. The lac glands are of two types. The first type includes pleuricellular glands which are restricted in their distribution to the perivaginal pore clusters. To the second type belong unicellular glands with separate ducts and prominent nuclei. Some of these are very much limited in their distribution, being present only along six serpentine areas of marginal duct clusters. These are flask-shaped in appearance, and have wide necks and prominent nuclei and nucleoli. Others belonging to the same category are distributed diffusely all over under the integument, excepting the six serpentine areas, and possess a round fundus with filiform ducts.

3. The gut of the lac insect consists of a club-shaped pharynx, an elongated œsophagus, a much-convoluted ventriculus, a recurrent intestine, a colon with a cæcum, and, lastly, the rectum. A pair of salivary glands are also present.

4. The pharyngeal wall is made up of a single layer of columnar epithelial cells with prominent nuclei. The greater part of it lies within the chitinous framework of the mouth, and at its oral end are present a pair of salivary glands whose ducts open into it. The œsophagus is a long, narrow tube of the same histological composition as the pharynx, and is drawn in for some distance into the interior of the colon, where it forms the convoluted ventriculus. The wall of the ventriculus consists of a layer of large conical cells the free ends of which bulge out towards the lumen. At the base of these cells is a prominent deeply-staining nucleus. This association of the ventriculus and the colon is a very interesting feature. The convolutions of the ventriculus are independent of the colon. The recurrent intestine may be said to consist of a proximal and a distal limb, the junction of the two being marked by the attachment of the Malpighian tubes. The wall of the intestine is thrown into folds, and the lumen is lined with a layer of chitinous intima. The wall of the colon consists of a layer of moderately elevated conical cells. The cellular nature of the wall of the colon is suppressed in the zone enclosing the convolutions of the crop. The rectum has a very thin wall. A few prominences in its wall are the only indication of its cellular character. The lumen of the rectum is lined by a chitinous intima which shows a few ridges. The Malpighian tubes, of which there is a pair, present a beaded appearance due to the distention of their cells with excretory matter. They are made up of two alternating rows of cells.

5. In common with most other Coccids, the female lac insect also produces large quantities of "honeydew," which is sought for by the ants. The belief that honeydew is secreted for the ants, and that the ants, in return, are of service to the lac insect in warding off their enemies, does not seem to rest on any positive evidence. This question has been discussed thoroughly in the preceding pages, and it has been shown that the honeydew is dependent upon a vital process for its production, and is not produced for the ants or, for the matter of that, for any other insect. Arguments have been brought forward negating the belief in the symbiotic relationship between ants and the

female lac insect. The prevalent belief that ants are injurious to a successful cultivation of lac has been shown to be without foundation.

6. The author has shown that the dorsal spine is not capable of discharging any of the functions hitherto assigned to it by various authors. At the same time it is difficult to imagine what function it could possibly discharge in the female lac insect.

7. The female lac insect possesses two pairs of spiracular openings. The anterior pair of spiracular openings is borne by the brachia, which are grooved on their outer margins to lodge the spiracular openings of the respective sides. Each spiracular opening leads into the cavara, from the base of which the main tracheal trunk arises, which, by further subdivisions, gives rise to a bushy tuft of trachea. The cavara is bounded by the peritreme, which bears numerous pores. The posterior spiracles are situated near the oral end of the insect, and, though built on the same plan, are smaller in size and lack muscular slips. There are tracheæ in association with these also.

8. Through the dimples of the brachial plates and the anacerores of the anal tubercle waxy threads are given off. It has been shown that these are not the attenuated extremities of the tracheæ, being formed by wax glands situated under the areas referred to, and hence of a waxy character. The structure of the wax glands has been dealt with, and they have been shown to resemble the wax glands of *Pseudococcus* and *Ceroplastes* in many respects.

9. There are three bundles of muscles. Two of these are attached near the mouth-parts on the one hand, and, on the other, are inserted in the interspaces between the anal tubercle and the brachia of the corresponding sides. The third bundle is inserted at the oral end near the œsophagus, on the one hand, and, on the other, extends into the anal tubercle, which it muscularizes. The correct morphological value of these muscular bundles has been indicated in the text.

10. No vascular vessel or pulsatile vessel was detected in the female lac insect.

11. The nervous system is represented by two separate ganglia, one of which is situated close to the colon-cum-rectum portion of the gut; the other lies close to the Malpighian tubes. The first of these represents the thoracico-abdominal ganglion of the larva, whilst the other is the cerebral ganglion. The thoracico-abdominal ganglion gives off a few nerves which innervate the interior of the insect.

12. The ovary of the female lac insect is an arboreal organ bearing numerous diverticula in which the embryos subsequently undergo development. The oviducts of opposite sides unite to form the uterus, which leads into the vagina. The female genital opening is situated on the anal tubercle. The receptaculum seminis consists of a stalk and a terminal chamber, and is attached to the oviducts just a little above the point where the two meet.

13. The wall of the ovary consists of a thin cellular layer. The oviducts have the same essential structure as the ovarian wall. The wall of the uterus consists of an internal layer of columnar epithelium resting externally on a layer of circular muscles external to which are the longitudinal muscle fibres. The vagina has the same structure as the uterus, but differs from it in having the cells of the epithelial layer more elongated and closely packed up on account of its being thrown into folds and in having the lumen lined by a chitinous intima. The receptaculum seminis has the same histological structure as the uterus, but no cell boundaries are distinguishable in its internal epithelial layer.

14. The oviducts open to the exterior quite independently of the rectum on one side of the anal tubercle.

15. The larvæ emerge through the female genital opening and not through the anus, spiracle, or by the rupture of the skin as described by many previous workers.

16. The death of the female lac insect seems to be due to the incapacity of the Malpighian tubes to store up any further quantity of waste matter when its cells, in the advanced stage of life, have become distended to the utmost. The Malpighian tubes, from larva onwards, gradually become laden with waste matter until they become distended to the utmost, when death, due to auto-intoxication, results. Similar instances in the Animal Kingdom are provided by the Ascidians and the Anurida.

11. REFERENCES TO LITERATURE.

1. BUGNION & POPOFF.—Le glandes cirières de *Flata marginella*. Bull. Soc. Vaud. tome xliii. 1907.
2. CARTER, H. J. — On the Natural History of the Lac insect (*Coccus lacca*). Ann. & Mag. Nat. Hist. London, 3rd series, vol. vii. 1861.
3. CHAMBERLIN, J. C. — A Systematic Monograph of the *Tachardiinæ* or Lac-insects (Coccidæ). Bull. Ent. Res. London, vol. xiv. pt. 2, October 1923.
4. CHAMBERLIN, J. C. — Supplement to a Monograph of the *Lacciferidæ* (*Tachardiinæ*) or Lac-insects (Homoptera-Coccidæ). Bull. Ent. Res. London, vol. xvi. pt. 1, 1925.
5. CHILDS, L. — The Anatomy of the Diaspinine Scale-insect, *Epidiaspis piricola* (Del Guer). Ann. Ent. Soc. America, vol. vii. no. 1, March 1914.
6. DUPOURT, L. — L'Insecte à Stick Lac. Bull. Econ. Indochine, new series, vol. xvii. no. 113, Mai Juin 1915.
7. GREEN, E. E. — The Coccidæ of Ceylon. Part v. 1922.
8. IMMS, A. D. & CHATTERJI, N. C. — On the Structure and Biology of *Tachardia lacca*. Kerr, with observations on certain insects predaceous or parasitic upon it. Ind. For. Mem. Calcutta, vol. iii. pt. 1, 1915.
9. JOHNSTON, C. E. — On the Internal Anatomy of *Icerya purchasi*. Ann. Ent. Soc. America, vol. v. 1912.
10. KERR, J. — Natural History of the Insect which produces the Gum Lacca. Phil. Trans. Roy. Soc. London, vol. lxxi. pt. 2, 1781, pp. 374-81.
11. KUWANA, S. I. — Notes on the Life-History and Morphology of *Gossypiera ulmi* Geoff. Bull. Imp. Centr. Exp. St. Japan, vol. i. no. 2, October 1907.
12. KUWANA, S. I. — Studies on the Japanese *Monophlebiniæ*. Contributions 1 & 2. Bull. Imp. Plant. Quar. St. Japan, nos. 1 & 2, 1922.
13. LAURIE, M. — Some Points in the Development of *Scorpio fulvipes*. Quart. Journ. Micros. Sc. vol. xxxii. pp. 587-97. 1891.
14. LEFROY, H. M. — The Cultivation of Shellac as an Agricultural Product. Agric. Journ. India, vol. iv. 1909, pp. 258-70.
15. LEFROY, H. M. — Indian Insect Life. Calcutta, 1909.
16. LEYDIG, F. — Zur Anatomie von *Coccus hesperidum*. Zeit. f. Wiss. Zool. Bd. v. 1853, pp. 1-12.
17. LUBBOCK, J. — On the Digestive and Nervous Systems of *Coccus hesperidum*. Ann. & Mag. Nat. Hist. London, vol. iii. 3rd series, 1859, pp. 306-11.
18. MACGILLIVRAY, ALEX. D. — The Coccidæ. Illinois, 1921.
19. MAHDIHASAN, S. — Classification of Lac Insects from a Physiological Standpoint. Journ. Sc. Ass. Vizianagram, vol. i. no. 2, 1923.
20. MASKELL, W. M. — On the Honeydew of the Coccidæ. Trans. & Proc. New Zealand Institute, vol. xix. 1886.
21. MATHESON, R. — The Wax-secreting Glands of *Pseudococcus citri* Risso. Ann. Ent. Soc. America, vol. xvi. no. 1, 1923.
22. MISRA, C. S. — The Cultivation of Lac in the Plains of India. Bull. Agric. Res. Inst. Pusa, Entom. Ser., nos. 28 & 142, 1912 & 1923.
23. MISRA, C. S. — Lac Culture in India. Proc. Third Entom. Conf. Pusa, 1919, pp. 782-800.
24. MISRA, A. B. — On the Internal Anatomy of the Female Lac Insect of the Genus *Tachardia*. Ind. Sc. Congr. Lucknow, Zool. Sect., 1923.

25. NEWSTEAD, R.—Monograph of the Coccidæ of the British Isles. Ray Society, 1900.
 26. ROMANES, G. J., & WALKER, A. O.—The Use of Ants to Aphidæ and Coccidæ. *Nature*, May 18, 1893.
 27. ROXBURGH, W.—*Chermes lacca*. Phil. Trans. Roy. Soc. London, vol. lxxxi. pt. 1, 1791, pp. 228–235.
 28. SASAKI, C.—On the Wax-producing Coccid *Ericerus pela* Westwood. Bull. Imp. Univ. Coll. Agric. Japan, no. 6, 1904.
 29. STEBBING, F. P.—A Note on the Lac Insect (*Tachardia lacca*), its Life-History, Propagation, and Collection. Ind. For. Rec. vol. i. pt. 1, 1908.
 30. STEBBING, F. P.—A Note on the Lac Insect. Ind. For. Mem. vol. i. pt. 3, 1910.
 31. STILLMAN, J. M.—On the Origin of Lac. Amer. Nat. vol. xiv. 1880.
 32. TARGIONI-TOZZETTI, A.—Studi Sulle Cocciniglie. Mem. Soc. Ital. Sci. Nat. vol. iii, 1867.
 33. VISART, O.—Contribuzione allo studio delle glandule cecripare delle Cocciniglie. *Revis. Patal. Veg.* vol. iii. 1896, pp. 39–48.
 34. WITLACZIL, E.—Zur Morphologie und Anatomie der Cocciden. *Zeit. f. Wiss. Zool.* vol. xliii, 1886, pp. 149–174.

12. LETTERING OF THE PLATES.

Alsm. Attachment of the longitudinal sternal muscles.
Anl.op. Anal opening.
Anl.tb. Anal tubercle.
Anl.tb.op. Opening for the anal tubercle.
Ant.sp. Anterior spiracle.
Bbh.int. Bulbous end of the intestine.
Brc. Brachium.
Brc.op. Opening for the brachium.
Brc.pl. Brachial plate.
Car. Caverna.
Ch.int. Chitinous intima.
Cir.mus. Circular muscle.
Clu. Colon.
Clu.cæ. Colon cæcum.
Clu.wl. Colon wall.
Clr.ep. Columnar epithelium.
Crb.gg. Cerebral ganglion.
Ctc. Cuticle.
Dct. Duct.
Diff.lc.gld. Diffuse lac gland.
Dor.sp. Dorsal spine.
Exc.gr. Excretory granule.
Fem.gn.op. Female genital opening.
Fem.rs.cl. Female resinous cell.
Fnd. Fundus.
Hyp. Hypodermis.
Lng.mus. Longitudinal muscle.
Lng.st.mus. Longitudinal sternal muscle.
Loc.lc.gld. Localised lac gland.
Mal.tb. Malpighian tube.
Mrg.dct.cl. Marginal duet cluster.
Mus. Muscle.

Nuc. Nucleus.
Nucl. Nucleolus.
Oes. Oesophagus.
Ovd. Oviduct.
Ovl. Ovariole.
Ovr. Ovary.
Ovr.wl. Wall of the ovary.
Ph. Pharynx.
Plr.lc.gld. Pleuricellular lac gland.
Prt. Partition.
Prv.pr.cl. Perivaginal pore cluster.
Prx.int. Proximal intestine.
Pst.sp. Posterior spiracle.
Rct. Rectum.
Rct.gg. Rectal ganglion.
Rct.wl. Wall of the rectum.
Rec.int. Recurrent intestine.
Res.enc. Resinous encrustation.
Res.vt. Resinous vault.
Slv.gld. Salivary gland.
Spr.op. Spiracular opening.
Spt. Spermatheca.
Spz. Spermatozoon.
Srp.ar. Serpentine area.
Stk. Stalk.
Trc. Trachea.
Trg.st.mus. Tergo-sternal muscle.
Ut. Uterus.
Vet. Ventricle.
Vet.con. Ventricular convolutions.
Vgn. Vagina.
Vnt.dct.cl. Ventral duet cluster.

EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. A. The female lac insect denuded of its resinous covering, $\times 5$. B. Twig of *Zizyphus jujuba* bearing lac encrustation. Natural size.
2. The resinous vault of the female lac insect showing three openings, two of which are for the lodgment of the brachia, and the other for the anal tubercle. There is no distinct opening for the anal spine, whose position is indicated by a depression. $\times 15$.
 3. The external characters of the female lac insect, diagrammatic. After Chamberlin.

PLATE II.

- Fig. 1. Marginal ducts cluster, highly magnified.
2. Ventral ducts cluster, highly magnified.
 3. Perivaginal pores cluster, highly magnified.
 4. Portion of the integument of the female lac insect in the region of the serpentine area, showing the arrangement and the characters of the localized and diffuse lac glands of the second type. $\times 150$.

PLATE III.

- Fig. 1. Vertical section of the integument in the region of a serpentine area presenting a sectional view of the above lac glands. $\times 100$.
2. Diagram of the pleuricellular lac glands belonging to the perivaginal pores cluster. $\times 350$.
 3. Schematic representation of the aboral part of the integument of the female lac insect, showing the position of the six serpentine areas where the localized lac glands of the second type are found.

PLATE IV.

- Fig. 1. The gut of the female lac insect. The pharynx and part of the oesophagus have been omitted. $\times 25$.
2. Schematic representation of the principal internal organs of the female lac insect *in situ*.

PLATE V.

- Figs. 1 & 2. Transverse sections of the colon with the enclosed ventriculus, showing the independence of the two structures. $\times 200$.
3. Transverse section of the two bulbous ends of the recurrent intestine, showing the independence of the two limbs. $\times 200$.

PLATE VI.

- Fig. 1. Slightly oblique section passing through the oesophagus, the bulb of the distal limb of the recurrent intestine and the colon with the contained ventricular coils. $\times 125$.
2. Transverse section of the intestine of the female lac insect. $\times 100$.
 3. Transverse section of the colon with the enclosed ventriculus, showing the entrance of the oesophagus and the colon caecum at its beginning. $\times 200$.

PLATE VII.

- Fig. 1. Transverse section of the rectum with the colon caecum opening into it. $\times 125$.
2. Transverse section of the rectum and the colon caecum. $\times 125$.
 3. Sectional view of the spiracle of the female lac insect, slightly diagrammatic. $\times 90$.
 4. The convoluted ventriculus teased out of the colon. $\times 125$.
 5. The spermatheca of the female lac insect. $\times 35$.
 6. The spermatozoon obtained from the interior of the spermatheca. $\times 500$.
 7. The anal tubercle, showing the independent courses and exit of the rectum, the uterus, and the vagina.
 8. The pharynx and the salivary glands of the female lac insect. $\times 40$.
 9. The rectal or thoracico-abdominal ganglion, usually found lying adjacent to the colon or the rectum. $\times 30$.

PLATE VIII.

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15. The Menstrual Cycle of the Primates.—Part III. The Alleged Breeding-season of Primates, with special reference to the Chacma Baboon (*Papio porcarius*). By S. ZUCKERMAN, M.A., M.R.C.S., L.R.C.P., Anatomist to the Society, and Demonstrator of Anatomy, University College, London.

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(Text-figure 1; Charts 1-6.)

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I. INTRODUCTION.

The question whether sub-human primates breed throughout the year, or whether they do so only during definite breeding-seasons, was discussed in a general way in Part I. of this series (Zuckerman, 1930, pp. 693-696). Reference was made to records of animals in captivity and to reports of travellers. As certain new knowledge about the Chacma Baboon of South Africa (*Papio porcarius*) has since accumulated, it is proposed to discuss the problem in greater detail in this paper. It is one that warrants careful consideration not only from the physiological point of view, but also because of its anthropological and sociological implications.

In my previous discussion I quoted several field reports, judging from which it would seem that the greater number of apes and monkeys have demarcated breeding-seasons. So many of these reports, however, conflict with each other, and others are of such doubtful value, that I found it impossible to come to any conclusion except in the case of the Rhesus Macaque (*Macaca mulatta*) and the Gibraltar Ape (*Macaca sylvana*).

According to C. H. (1880) and Sclater (1900), the young of the Gibraltar Ape (*Macaca sylvana*) are born in the spring and early summer. These reports were accepted as probably reliable, because the animal is one that can be easily observed, living as it does in a state of semi-domestication in a very restricted area. They cannot, however, be accepted as final in the absence of details regarding the animal's ovarian and uterine cycles.

According to Heape (1894, 1897)* the Rhesus Macaque "has one or more definite breeding-seasons." This opinion he based upon the fact that "a very large proportion"—probably not less than four-fifths of 230 wild monkeys sent to him in January, February, and March—"either had embryos in an advanced stage of development *in utero*, or had recently borne young." Most of the remainder—the number is not given—had not reached puberty, and, after excluding other "doubtful cases," he was left with seventeen non-pregnant females for study.

From this account, however, it is impossible to make any definite estimate of the proportion of females that were actually pregnant or lactating. Moreover, very little is said of the sizes of the foetuses, although Heape does mention that in two specimens he found "embryos of a stage probably similar to a six-weeks' old human embryo," while the rest were "nearly full grown." Nothing is said of the probable ages of those that had already been born, or of the conditions of the ovaries and uteri of those that had aborted their young. In fact, all stages of the menstrual cycle, of pregnancy, and of lactation may have been represented in his material. Much more evidence is therefore necessary before the existence of a breeding-season in the Rhesus Macaque can be accepted as proved.

Very little has been recorded about the breeding of the genus *Papio*, with which this paper is largely concerned. Loveridge (1923) states that the Yellow Baboon of East Africa (*Papio cynocephalus*) breeds at all times of the year, basing this statement upon the fact that he saw females with young in May, July, August, and October; while Stevenson-Hamilton (1912) writes that the young of *Papio porcarius* are born between November and February.

New data, that conflict with Stevenson-Hamilton's statement, and prove that *P. porcarius* has no demarcated breeding-season, are given in Section 3 of this paper†. They are based upon observation of living wild baboons and upon anatomical material collected in South Africa.

2. FIELD METHODS.

(A) Recognition of the Various Phases of the Reproductive Cycle of Baboons.

It was shown in Part I. that a study of sexual skin changes, particularly in baboons, indicates that follicular hormone effects are usually suppressed during pregnancy in primates. Subsidence of sexual-skin swelling coincides with ovulation, and if fertilization then occurs, the sexual skin does not show signs of activity during gestation ‡.

* Only the 1894 paper was quoted in Part I. (1930) of the present series.

† A description of the morphological changes occurring during the complete reproductive cycle of the baboon will be given in Part V. of this series of papers on the Menstrual Cycle.

‡ It is possible, therefore, to calculate the duration of pregnancy, in baboons and other primates, as the time that separates parturition from the last observed subsidence of swelling previous to it. Acting on this principle, pregnancy was diagnosed in a Pig-tailed Macaque (Part I. Chart 3, p. 707) and in a Hamadryas Baboon (Part I. Chart 10, p. 713.), the paper going to press before either had given birth. This they did later, the macaque after 171 days', and the baboon (Wa.) after 183 days' gestation.

The South African data recorded in Section 3 (A) of this paper prove the above deductions, for in no pregnant baboon that was shot was there any sign of sexual-skin activity.

The sexual skin is also inactive during the first few months of lactation, during which time the ovaries are inactive. The length of this lactation interval in baboons is not established. Thus far I have had only one opportunity of observing its full extent in the species *P. hamadryas*. An animal, Wa. (Part I. p. 713.), after 183 days' gestation, nursed her male baby for 149 days before her sexual skin began to swell. The sexual skin of another *P. hamadryas*, M., was quiescent for the nine months she lived after the birth of a female baby, which she nursed up to her death. At autopsy it was found that she had a chronic septic endometritis. Another female of this species, Sm., showed no signs of sexual-skin activity during the 99 days her baby lived.

The lactation interval in a Pig-tailed Macaque (*M. nemestrina*) lasted eight months (Part I. p. 734.).

Determination of the Stage of Lactation.—As milk can be expressed from the mammary glands of most wild parous baboons, and as neither external nor internal genitalia vary during the lactation interval, it is necessary, in order to find out the stage of lactation in which any particular nursing female may be, to determine the age of her baby. This cannot be done with certainty, but an estimate can be made by examination of its teeth.

Unfortunately, there are no published data about the times of tooth eruption in either *Papio porcarius* or in any other baboon. The only publication, known to me, on the times of milk-tooth eruption in an Old World monkey is Spiegel's paper on the Java Macaque (*Macaca irus*) (1929). It is undoubtedly a far stretch from a macaque to a baboon; but, in the circumstances, reference to Spiegel's figures cannot be omitted, for, in spite of the disparity in size between adult baboons and adult Java Macaques, gestation in both lasts about the same length of time*, and it is conceivable that the early post-natal growth stages, like the intra-uterine, may be approximately the same in these two Old World monkeys.

Safer estimates of age can be made by reference to certain figures, collected in the Zoological Gardens, relating to the times of milk-tooth eruption in *Papio hamadryas*, a species allied to *porcarius*, and by reference to the later history of two, (b) and (c), young *P. porcarius* recorded in Section 3 (A) below.

The young of *P. hamadryas* are born toothless. The only teeth that were in place in a baby that died in the Zoological Gardens when 64 days old (Sc., b) were the medial milk incisors. The lateral incisors had cut the gums, but were not yet in place. Another baby (Sm., b) died when 99 days old. The only teeth that were in place were the eight milk incisors. The tips of the canines had pierced the gums, and the crowns of the first lower molars were visible. A third baby (Wa., b) died when 156 days old. It had all its milk teeth except the second molars. The first were not quite in place.

A young male *P. porcarius* (b) was caught on May 4th, 1930, and lived 16 days in captivity. When caught, its four medial incisors were the only teeth through the gums. By the time it died the tips of its lateral incisors had cut. At death it weighed 1347 gms.

A young female *P. porcarius* (c) was caught the same day. She is still alive. On the day of capture her eight milk incisors were in place, and the tips of her milk canines and anterior molars were through the gums, but not quite in

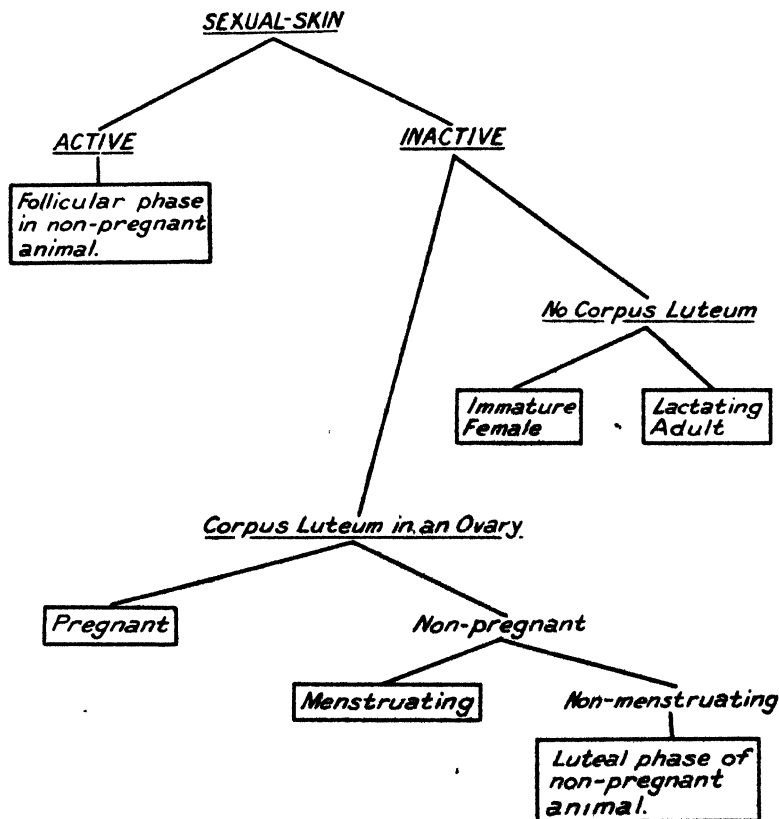
* According to Spiegel it lasts from 160 to 170 days in the common Java Macaque, and, as was pointed out in Part I. (1930), from 154 to 185 days in the Hamadryas Baboon (*P. hamadryas*).

place. Her posterior milk molars cut the gums on September 25th, by which time her canines and anterior molars were fully in place. Her weight on June 21st was 2930 gms., and on September 30th 3750 gms.

These data of *P. porcarius* and *P. hamadryas* show that quite five months may intervene between the eruption of the anterior and posterior milk molars, and that the anterior may not cut the gums before 99 days. Thus the eruption of the milk teeth in the baboon may take as long as eight months.

The Complete Reproductive Cycle.—Gestation in the Hamadryas Baboon lasts 154 to 185 days, while the phase of sexual-skin quiescence following

Text-figure 1.



Plan for recognition of various phases of reproductive cycle of Baboons.

parturition may last 5 months. Gestation and lactation in one female (Wa.) lasted 332 days.

A complete reproductive cycle in the baboon—the smallest interval of time between two births by the same female—lasts, therefore, about a year.

For purposes of field observation these facts may be summarised as follows :—

If the sexual skin is swollen, the animal is non-pregnant, and in the follicular

phase of the menstrual cycle. An ovary will be found to contain a prominent follicle.

If the sexual skin is inactive, the animal may be (a) in the luteal phase of a menstrual cycle, or (b) menstruating, or (c) pregnant, or (d) lactating.

- (a) This phase is easily determined by the non-pregnant state of the animal and the presence of a corpus luteum in an ovary.
- (b) and (c) These phases are self-evident.
- (d) This phase is also self-evident, and is associated with inactive ovaries and uterus.

(B) *Practical Implications of the Occurrence of a Breeding-season.*

Reproductive periodicity common to all individuals exists in species with fixed mating- and breeding-seasons. The mating-season recurs periodically at the same time of the year, so that the females in œstrus, pregnant females, or lactating females are found usually only at fixed times. In such a species, therefore, the greater number of adult females will be all at approximately the same reproductive phase at any given time of the year. The actual degree of reproductive correspondence will, of course, depend on the length of the mating-season.

The Canadian Porcupine (*Erethizon dorsatum*), has a short, clearly-marked mating-season from the beginning of November to the beginning of December. The gestation period is sixteen weeks, and Struthers (1928), judging from the size of the embryos, found that the pregnant females were all at approximately the same state of pregnancy at the same time. A similar example is Steller's Sea-Lion (*Eumetopias stelleri*). According to Rowley (1929), the breeding-season of this animal is from June 15th to July 15th, irrespective of weather conditions. Gestation lasts approximately twelve months. The females come ashore for the breeding-season, give birth to their pups, and within a few days seek the bull. At any time of the year, therefore, most of the females of this species will be in practically the same reproductive phase.

Where the breeding-season is prolonged there will, of course, be less reproductive correspondence between the females of the species. In the domestic mare, for instance, there may be a barren mating-season of eight months. As gestation lasts eleven months there will be, at certain times of the year, females that are nursing young foals together with females that are still in the early stages of pregnancy.

In small polyœstrous mammals, where the gestation period is short, and where several pregnancies may occur in the same female in one breeding-season, there may, of course, be no close correspondence in regard to reproductive phases. But even in such animals there will be one phase in the reproductive cycle, the anœstrus, when all females will be approximately in the same condition.

3. FIELD OBSERVATIONS ON *PAPIO PORCARIUS*.

(A) *Observations.*

The observations of the Chacma Baboon (*Papio porcarius*) recorded below were made in South Africa, where baboons are regarded as vermin, during the months of March, April, and May 1930. They were made in various parts of the country: most of the time was spent in the Eastern Province.

- (a) During the last week of March and the first week of April a pack of

baboons, consisting of about 25 individuals, was under observation on the farm Stradbroke, which is near the railway-siding of Tafelberg in the Eastern Province. One female belonging to this troop was in œstrus, showing full sexual-skin swelling. Another was nursing a very small baby, which hung on to the hair of her belly. A third had a baby old enough to move from her belly to her back when being carried. Neither of these two nursing females showed any sign of sexual-skin swelling. No other female of this troop was either in full "heat" or nursing.

(b) Early in April a captive female baboon was seen on the farm Kleinpoort, which is near Grahamstown, in the Eastern Province. She had been caught there nine years before. I was told by her owner that she undergoes an uninterrupted series of monthly menstrual cycles, bleeding being followed by swelling of the sexual skin. When seen on the 4th April her sexual skin was swollen, but a little slack, and I was told that the swelling was on the decline. On the 5th of May I saw this female a second time, and found her sexual-skin fully swollen and tense. These two observations indicate a cycle length of, roughly, thirty days.

A wild female baboon (M. 32) was shot on this farm on April 10th. She was pregnant, the embryo being approximately 6 mm. from rump to vertex*. Her sexual skin was quiescent.

(c) During the third week in April observations were made on a pack of baboons that roamed a mountainous plateau near Piquetberg, in the Western Province. The pack was too big to make any accurate estimation of its size, but it was at least a hundred strong. Several females carried babies, and these were of all sizes; numbers showed full sexual-skin swelling, while others either showed none or were in stages intermediate between the quiescent and fully active sexual-skin phases.

(d) In the fourth week of April two female baboons were seen in the Johannesburg (Transvaal) Zoological Gardens. Both showed a moderate degree of sexual skin swelling.

(e) On May 4th fourteen female baboons were shot on the farm Bosky Dell, near Grahamstown, in the Eastern Province. Two of them were immature. One of the remaining twelve (No. 23) showed almost full sexual-skin swelling, and her right ovary was distended with a ripe follicle. The sexual skin of a second (No. 26) was inactive, and the vagina contained blood. Microscopic examination of the uterus proves that she was menstruating. Two (M. 18 and M. 19) were in the phase of sexual-skin quiescence. Each had an ovary containing a large corpus luteum. Neither had any prominent follicles. For reasons fully set out in Part I. it is clear that these two animals were in a premenstrual phase. Five females were pregnant. No. 27 contained an embryo 2.5 mm. in length; No. 24 one 16.5 mm.; No. 22 one 19 mm.; No. 25 one that measured 65 mm. from its vertex to the root of its tail and 31 mm. from its occiput to the tip of its snout; and No. 29 contained an apparently full-term male fœtus that measured 230 mm. from its vertex to the root of its tail and 104 mm. from its occiput to the tip of its snout, and weighed 1134 gms. (A male *P. porcarius*, approximately two months old, weighed 1347 gms. (Section 2 (A)).

* All measurements mentioned here are somewhat approximate, as it was thought inadvisable to disturb unduly the relations of the embryos at this stage of the investigation. If necessary, corrections will be made at a later date, when the study of the embryological material I collected is completed.

The remaining three, Nos. 20, 21, and 28, were nursing*. Two of the babies, (a) and (b), were males of about the same size, and, judging by their teeth, of approximately the same age. (The only teeth they had were the four medial milk incisors.) The third (c), a female, was a somewhat older animal, judging from her size and teeth. Her eight milk incisors were in place, and the tips of her milk canines and anterior molars were through the gum, but not quite in place.

Judging from Spiegel's data for the Common Macaque (p. 327), the two males, (a) and (b), were between three and four weeks, and the female (c), about two and a half months old when caught. Judging from the data regarding the eruption of milk teeth in baboons given on p. 327, it would appear that the two male *Chacma* babies, (a) and (b), were at most two months old, whilst the female, (c), was about four months. The latter are the more likely estimates.

On the same day that the above material was obtained (4/5/30) other female baboons were seen, some nursing and others in different stages of sexual-skin activity.

A week later (11/5/30) another female (No. 34) belonging to this pack was shot. She was pregnant, her uterus containing an embryo approximately 14.5 mm. in length. Her sexual skin was in the inactive state.

(f) The last observation to be recorded here concerns a female baboon (No. 37) shot on the farm Stradbroke, in the Eastern Province, on August 30th. Her sexual skin was inactive, and she was nursing a baby.

(B) *Conclusions from Field Data.*

The reproductive phases of the adult female baboons shot on May 4th at Grahamstown were practically all different from each other, and were representative of almost all stages of the complete reproductive cycle, which, as pointed out on p. 328, lasts approximately a year.

Some were non-pregnant, some were in the early stages of pregnancy, and one contained a full-term foetus: others, again, were lactating, and one of these, judging by the age of her baby, would soon have restarted her normal menstrual cycle.

This disparity between the different females proves conclusively that female *Chacma* Baboons can, and do, become pregnant at all times of the year in the neighbourhood of Grahamstown. There can be no doubt that at all times of the year there are, in that district, female baboons experiencing menstrual cycles accompanied by ovulation, and also that there are at all times males that are potent and fertile.

Unfortunately, I did not obtain a series of pregnant females from any other district; but in the region of Tafelberg, which is a little more than a hundred miles from Grahamstown, I saw nursing and oestrous females together in the same troop. In the neighbourhood of Piquetberg, in the Western Province,

* During the hunt the three babies were separated from the carcasses of their mothers; it was impossible afterwards to pick out the latter just by inspection of all the baboons that had been shot. They were later identified by dissection of their mammary glands and by examination of their ovaries, which were smaller than those of any of the other females, and appeared to be inactive. (The cycle is suppressed during lactation.) It was also found later that the uteri of these three females were in the same condition. The lumen was widely open and the endometrium was far thinner than that in any of the other non-pregnant uteri. The possibility of any mistake having been made in their identification was proved to be more than remote when examination of the reproductive organs of a definitely lactating baboon (No. 37) showed them to be in exactly the same condition.

I also saw, in another troop, nursing mothers together with females showing all stages of sexual-skin swelling.

There is no evidence that reproductive conditions vary * in different parts of the country, and my own observations definitely indicate that *breeding at any time of the year is a characteristic of P. porcaurius* †.

4. TIMES OF BREEDING IN OTHER PRIMATE SPECIES.

As pointed out above (pp. 325, 326), there are no reliable data relating to the times of breeding of Old World monkeys and apes in their wild condition other than those presented in the preceding section regarding the Chacma Baboon. A certain amount of information about the breeding of captive monkeys is available. If, however, the widely-held view as to the effect of external conditions on the times of the mating- and breeding-season—expounded at length by Heape in 1900—is to be trusted, such information is inadmissible as evidence in the solution of the problem of the breeding-habits of wild monkeys. But, in spite of its general acceptance, this view does not seem to rest on any firm foundation.

(A) *Effect of External Conditions.*

Mating-seasons are usually explained on the teleological principle that it is necessary for the young to be born at a favourable time of the year—that is, when climatic conditions are favourable and food is plentiful. It is also assumed that mating is timed in accordance with this principle, becoming fixed, through natural selection, according to the length of gestation and according to the particular needs of the young of the species. Thus Marshall (1922) writes: "The restriction of the breeding-habit to certain seasons may have been brought about under the influence of natural selection to meet the necessities of the offspring"; while, according to Westermarck (1921), this principle explains why "every month or season of the year is the pairing time of one or another species of Mammals."

Considered in a very general and broad way, these views are an attractive explanation of the existence of mating-seasons; and, moreover, they enable one to explain why some mammals give birth, not in the spring, but in winter, and why two different species of mammals living in the same locality may yet give birth at different times of the year. But they are views that lie outside the reach of scientific proof, owing to the fact that they rest on an intangible concept, namely, "necessities of the offspring."

Heape (1900) objected to these views on the ground that there were mammals, for instance the bat and the roe-deer, whose mating-seasons are separated from the time when they give birth by periods longer than are actually necessary for the intra-uterine development of the young ‡. He suggested, as an

* According to the classical conception of the nature of breeding-seasons, discussed in the following section, an animal is more likely to breed during a demarcated part of the year if the area it inhabits shows distinct seasonal changes, that is, if the cold-warm, dry-wet seasons are sharply marked. Probably no area in South Africa shows seasonal changes better than does the Grahamstown area, which is also as inhospitable to baboons, from the point of view of food-supply, as is any area in the country inhabited by the animals. Yet the baboon living under these conditions breeds at any time of the year. On this view it is unlikely, therefore, that the baboon has demarcated breeding-seasons in any part of South Africa.

† The subspecific differences that have from time to time been described in the species *P. porcaurius* are of no obvious importance from the reproductive point of view.

‡ It is said that in the bat the sperm introduced into the vagina do not fertilize an ovum until several months have passed; and that in the roe-deer the fertilized ovum remains quiescent in the segmentation stage for a considerable period.

alternative theory, that certain "climatic" factors "essentially govern" the time of occurrence of the mating-season, and that "climatic," "individual," and "maternal" factors influence its duration and its recurrence. Climatic factors include temperature and seasonal changes, and cyclical variation in the quantity and nature of food-supply; individual factors he considered to be those morphological and physiological characteristics that are peculiar to the species; while maternal influences are the length of gestation, lactation, and the period of recuperation following on these two phases*.

The hypothesis that the time of the mating-season is determined by climatic factors is chiefly supported by such observations as indicate that the time of mating of a species differs "in accordance with the nature of the country in which it lives" (Heape, 1900). Heape also claimed that artificial conditions, for instance those of domestication and captivity, increase the duration and number of the mating seasons of some mammals. The hypothesis is also clearly related to the fairly common belief that most mammals living in temperate and cold regions have restricted mating- and breeding-seasons, and that, on the other hand, many mammals living in equatorial regions or in areas where there is a fairly constant food-supply mate and breed at all times of the year†.

Far less is known about the breeding-habits of tropical mammals than about those of mammals living in temperate regions. The literature on the question contains many conflicting observations. According to Berger, for instance (quoted by Alverdes, 1927), tropical African mammals give birth during the dry season, which varies in the time of its appearance from region to region; while, according to Schuster (1930), though the greater number of tropical mammals have breeding-seasons that are usually more prolonged than those of European mammals, there are some that may give birth at any time of the year.

In spite of the general acceptance of the view there is, however, no clear evidence that external conditions do exercise any important influence on the time and extent of mating-seasons. Few of the observations on the mating-seasons of wild mammals recorded by Heape in 1900 are exact. Most of his statements on the subject are qualified by the word "probably," and his conclusion that captive conditions prolong the mating-seasons of wild mammals was arrived at by comparing his own uncertain records of their breeding-habits in the wild with statements made by keepers in the London Zoological Gardens regarding the habits of the same animals in captivity. These statements were often incorrect. But, in any case, in the absence of definite knowledge about the breeding-habits of most wild mammals, the records‡ of births in the London Zoological Gardens afford no evidence for the view that captive conditions prolong mating-seasons.

Numerous observations conflict with Heape's view that the mating-seasons of mammals are directly influenced by external conditions.

Baker, for instance, who has investigated the breeding-season in wild mice (1930), found that there is "no correlation between the severity of the winters and the amount of reproduction during them." There was, for instance, a complete cessation of reproduction in *Apodemus sylvaticus* in the winter of 1925-26; a less complete cessation in that of 1926-27; while reproduction

* There seems to be no reason for separating "individual" from "maternal" factors, as the latter are part of the former.

† At the time Heape proposed his theory (1900) he was unaware that some animals other than monkeys experience in their wild state, in the absence of pregnancy, a continuous series of diestrous cycles.

‡ These records are being arranged for publication.

continued, with only a small break, throughout the winter of 1927-28. As he writes, this would be "easily understandable if each winter had been warmer than the one before; but this was not the case." He also gives an even more forcible demonstration of the relative unimportance of temperature in determining sexual activity. No fecund adult males were caught in February of 1926, whereas all males caught in March were fecund, even though March was actually colder than February. If, therefore, the amount of reproduction is controlled by environmental factors, then it would seem (a) that temperature certainly cannot be very important, and (b) that it cannot have any effect by itself.

Light, too, appears to be an unimportant factor in determining the onset or extent of reproductive activity. Hill and Parkes (1930) exposed two anoestrous ferrets to ultra-violet ray irradiation, but found that this had no effect on the animals' reproductive inactivity. The ferret, which may be considered a domesticated animal, has an anoestrus that lasts from late August until the end of March. In laboratories it is kept under unvarying conditions, yet its mating-season remains fixed between April and August. As Hill and Parkes point out, it is difficult to imagine what environmental changes take place during April in an artificially-heated animal house not particularly accessible to direct sunlight that may determine the onset of reproductive activity. Baker also considers this question, and, by contrasting the diurnal Bank-Vole (*Eutamias glareolus*) with the nocturnal Field-Mouse (*Apodemus sylvaticus*), comes to the conclusion that neither light nor periods of activity can be factors controlling the breeding-season in these two animals.

The effect of food on reproductive activity has been better studied than that of any other external factor. Numerous experiments have shown that deficient diets, leading to inanition, cause cessation of reproductive activity in laboratory mammals, and observation has shown that the same is true in the case of man; while in the case of the sheep it is well known that rich feeding increases fertility by increasing the number of twin births. But there is no evidence that clearly proves that artificial rich feeding ever increases the duration of a mating-season beyond what can be considered its natural limits. It is almost certain, for instance, that increased quantity of food would not prolong that of the ferret throughout the year.

The relative independence of breeding activity, so far as external conditions are concerned, is also clearly seen when one contrasts the habits of closely-allied animals. The Bushbuck (*Tragelaphus oryx*) and the Reedbuck (*Redunca redunca*), for instance, live in the same area, eat much the same food, and are exposed to the same climatic conditions; yet they differ considerably in their breeding-habits. According to Schuster (1930), the Reedbuck breeds throughout the year, the Bushbuck only in a demarcated season. The Grey Seal (*Halichoerus grypus*) and the Common Seal (*Phoca vitulina*) have similar habits and the same distribution. Yet the Grey Seal gives birth in February and the Common Seal in June (Lydekker, 1895). And to give a last example, Franklin's Ground-Squirrel (*Citellus franklini*) and the Yellow Ground-Squirrel (*Citellus richardsoni*) live under much the same conditions in the same area. Yet the Yellow Squirrel regularly comes up after hibernation in the middle of April, whatever the weather, and then starts mating, whereas the Franklin Ground-Squirrel does not emerge until three weeks later (Seton, 1910).

These differences would be inexplicable on the view that the time of the mating-season is determined by external conditions.

What evidence there is, therefore, is against the widely held view that external conditions play any important part in determining the time or extent of mating-seasons. According to the present state of our knowledge, it would

seem that the breeding behaviour of a species is determined by "individual" factors—that it is something inherent in the species. An animal is either capable of giving birth at any time of the year, like the Chacma Baboon, or it does so in a restricted breeding-season, like the ferret. The reason that one animal has a restricted breeding-season, while another is capable of reproduction at any time of the year, does not seem to depend upon external factors, but upon fundamental biological differences between the two animals.

As the evidence against the view that external conditions determine the time and extent of mating-seasons, though strong, is inconclusive, it is interesting to consider the question of the breeding-times of primates from two aspects: (a) that the view is correct, and (b) that it is incorrect. Actually however, both considerations lead to the same conclusion—that Old World primates breed all the year round.

(B) *Geographical Distribution and Breeding-habit.*

If external conditions do determine the time and extent of an animal's breeding-season, then (1) the records of monkey births in captivity do not necessarily give any indication of the times when monkeys give birth in their wild state; and (2) the fact that the Chacma Baboon can give birth at any time of the year (Section 3, p. 332) would, for reasons given below, lead one to expect that practically all Old World monkeys and apes breed throughout the year.

This baboon lives farther south of the Equator than does any other Old World primate, extending as far as 35° S. latitude; in fact, it lives farther from the Equator than nearly all* other Old World primates. Moreover, it lives under conditions that are generally less favourable than those to which other primates are exposed. The Yellow Baboon of East Africa, for instance, is often found in evergreen forests; most of the macaques live under conditions which, if they are no better, are certainly no worse than those of the Chacma Baboon, and the same is true of the Langurs; while the monkeys belonging to the genera *Colobus*, *Cercopithecus*, and *Cercocebus* live in obviously better conditions. They are found mainly in the equatorial parts of Africa in evergreen forests and in regions with equable climates. The habitat of the anthropoid apes is similar. Apes are not subjected to severe climatic changes, and they always have a profuse food-supply at their command.

If, then, external conditions play any big part in influencing the breeding behaviour of a species, the Chacma Baboon would be more likely to show a restricted breeding-season than most other Old World primates. But, from the facts recorded in Section 3A above, it is almost certain that this species breeds throughout the year. *From this point of view, therefore, most primates would also be expected to breed throughout the year.*

(C) *Records of Primate Births in the Zoological Gardens, London.*

If, as seems more probable, external conditions do not play any big part in determining the time and extent of an animal's breeding-season, it follows (1) that it is unsafe to infer the breeding-habits of one animal from the known breeding-habits of a related animal. On the other hand, it also follows (2) that records of monkey births in captivity probably give a very good indication of the breeding-habits of wild monkeys. Captive conditions may cause sterility

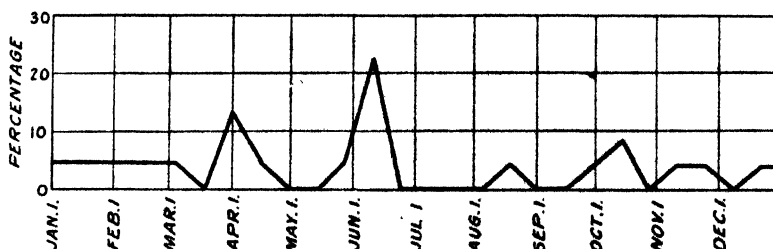
* *Macaca fuscata* and *Macaca tcheliensis* live in the Manchurian subregion of the Palearctic Region, the former extending as far north as 41° N. latitude. Among those that live as far away as *P. porcarius* are *Macaca silenus*, *Macaca assamensis*, and *Pithecius romellanus*.

in an animal; but, as pointed out above, there is practically no evidence that they increase reproductive power. The times when a monkey breeds in captivity are, therefore, presumably times when it would breed in its natural habitat.

The Zoological Society's records of monkey births go back to 1834, and although they have been few and far between, their statistical value is enormously increased by the fact that they have been spread over a large number of years. The records given below have been taken from the Society's "Occurrences," lists of "Monthly Additions," and "Vertebrate Lists," particularly the 10th edition prepared by Major Flower, who also very kindly lent me his notes relating to these records, and to records of *P. hamadryas* births that have occurred in the Giza Zoological Gardens, Egypt.

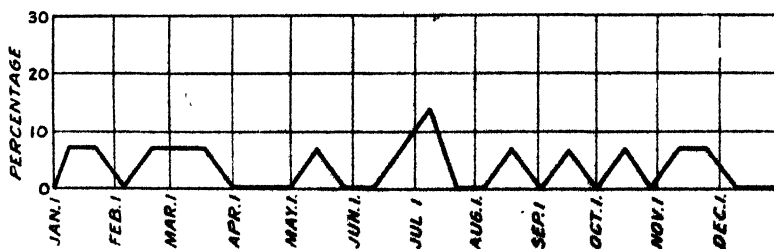
The data have been arranged as follows:—(a) A percentage frequency curve for the breeding of *M. mulatta* (Chart 1). (b) A percentage frequency curve for the breeding of *M. irus*. In this curve are included not only the births that have occurred in the London Gardens, but also four that have occurred elsewhere (*vide infra*) (Chart 2). (c) A composite curve of (a) and (b), including four records of births of hybrids between *M. mulatta* and *M. irus* (Chart 3). (d) A percentage frequency curve for the breeding of *P. hamadryas* in the London Gardens (Chart 4). (e) A percentage frequency curve for the breeding of *P. hamadryas* in the Giza Gardens between 1909 and 1923 (Chart 5). (f) A composite curve of (d) and (e) (Chart 6). (g) A list of other primate births.

Chart 1.



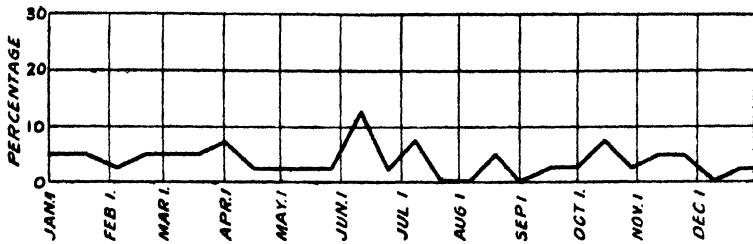
Frequency curve showing percentage distribution in the different months of the year of 22 Rhesus Macaque births (*M. mulatta*) occurring between 1846 and 1931. 21 occurred in the London Zoological Gardens, the 22nd in University College, London.

Chart 2.



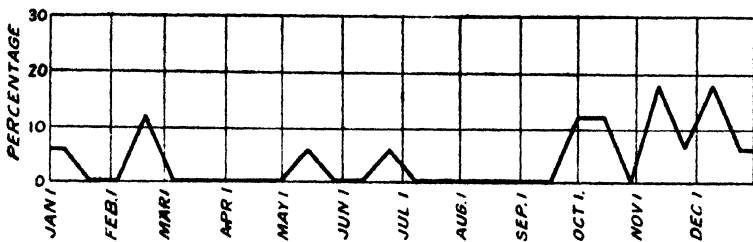
Frequency curve showing the percentage distribution in the different months of the year of 14 Common Macaque births (*M. irus*) occurring between 1884 and 1930. All except four (p. 339) occurred in the London Zoological Gardens.

Chart 3.



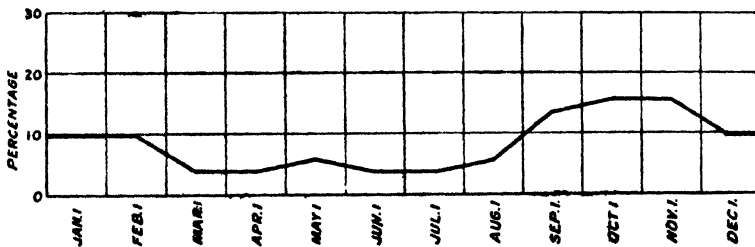
A composite curve of the curves in Charts 1 and 2, including 4 records of births of hybrids between *M. mulatta* and *M. trus*.

Chart 4.



Frequency curve showing percentage distribution in the different months of the year of 17 Hamadryas Baboon births (*P. hamadryas*) occurring between 1862 and 1930 in the London Zoological Gardens.

Chart 5.



Frequency curve showing percentage distribution in the different months of the year of 52 Hamadryas Baboon births (*P. hamadryas*) occurring between 1909 and 1923 in the Giza Zoological Gardens, Egypt. Data from Major S. S. Flower.

Chart 6.



A composite curve of curves in Charts 4 and 5.

List of Births.

Pithecus aygula (= *Semnopithecus pileatus*). Capped Langur.

7/4/1912, 27/9/1913, 22/1/1915, 22/11/1915.

Cercopithecus sabæus (= *C. callithricus*). Green Monkey.

31/1/1835, 13/7/1873, 22/2/1890.

Cercopithecus pygerythrus (= *C. lalandii*). Vervet Monkey.

8/6/1849, 11/7/1850, 31/3/1853, 18/3/1855, 23/3/1855, 11/6/1893.

Cercocebus fuliginosus. Sooty Mangabey.

31/7/1844, 5/6/1912.

Macaca radiata (= *Macacus sinicus*). Bonnet Monkey.

27/4/1843, 30/5/1876, 3/4/1885, 12/12/1908.

Another animal of this species, kept by Dr. C. Dobell, F.R.S. *, at the National Institute of Medical Research, Hampstead, gave birth to a still-born baby on the 26/2/1927.

Macaca fuscata (= *Macacus speciosus*). Japanese Ape.

10/1/1906.

Macaca nemestrina (= *Macacus nemestrinus*). Pig-tailed Monkey.

13/9/1857, 22/9/1913, 12/12/1914, 5/7/1928, 6/6/1930.

Macaca sylvana (= *Macacus inuus*). Barbary Ape.

17/5/1914.

Hybrid between *Mandrillus sphinx* (= *Cynocephalus mormon*) F. and *Macaca irus* (= *Macacus cynomolgus*) M.

13/10/1878.

Hybrid "supposed to be between *Cercopithecus callitrichus* (= *C. sabæus*) M. and *Macacus erythræus* (= *Macaca mulatta*) F."

22/3/1873.

Hybrid between *M. irus* M. and *M. nemestrina* F.

1/3/1906.

Hybrid between *M. mulatta* and *M. radiata*.

8/2/1846.

The following New World monkeys have been born in the London Gardens :—

Haple jacchus (= *H. pencillata*). Black-eared Marmoset.

29/5/1892, 2 born. 22/3/1832, 2 born. 6/7/1839, 3 "Common Jacchus Monkeys" born dead.

Major Flower has a record of marmosets being born in England on 1/1/1835, while Miss Hume, of the Lister Institute, tells me that recent marmoset births in her colony of monkeys have occurred at such dates that one can no longer see in her total records any tendency for births to group at any particular times of the year (see Part I. p. 696).

* The falls in weight occurring round the 380th, 530th, and 740th days in the growth-curve of a *M. mulatta*, constructed from Dr. Dobell's data and given on p. 704 of Part I, of this series, were due to emetine treatment.

I now have references to 17 marmoset births that have occurred in England. December is the only month in which young have not been born.

Leontocebus rosalia (= *Midas rosalia*). Silky Marmoset.
13/11/1872.

Cebus apella (= *C. capucinus*). Weeper Capuchin.
2/9/1895.

Cebus capucina (= *C. hypoleucus*). White-throated Capuchin.
3/7/1849.

Mention can be made here of dates of monkey births occurring in the Pasteur Institute, Tunis, recorded by Nicolle and Wetterle (1930): *Cercopithecus sabæus* on 4/6/1928 and 26/5/1930, and *M. cynomolgus*=*M. irus* on 2/1/1929. The latter has been included in Charts 2 and 3.

Spiegel (1930) records births of *Macaca irus* occurring in Tübingen on 18/10/1928, 20/6/1928, 26/2/1930. These also have been included in Charts 2 and 3.

These records indicate clearly that monkeys can conceive at any time in captivity, and presumably, therefore, like the baboon, at any time in the wild.*

5. SEASONAL VARIATION IN BIRTH-RATE.

The Zoological Society records do not provide enough data about any single monkey to tell whether or not the frequency of births has any seasonal variation.

Hartman (1929), from a study of 19 breeding records of his experimental colony in Washington, concluded that such a variation does exist in the birth-rate of the Rhesus Macaque (*M. mulatta*). Laparotomies on a number of females in the period May to August showed inactive ovaries, and he therefore inferred that ovulation does not usually occur during those months, though menstruation may go on with perfect regularity.

This conclusion is similar to that reached by Heape (1894, 1897) for *M. mulatta* and *P. entellus*, and by Van Herwerden (1905) for *M. irus*. Heape's inconclusive evidence in favour of the view that the Rhesus Monkey has a breeding-season was examined in Section 1 of this paper. It is now necessary to examine the data from which both he and Van Herwerden inferred that these monkeys do not ovulate during part of the year.

Heape's material consisted partly of 108 wild *Entellus* Langurs that were sent him between January and March (1894). A considerable number of these had already borne young and were nursing. Six had just given birth, and one was in the process of aborting an "advanced embryo." "About fifty"—from his records 48—of the non-breeding remainder were killed and their reproductive organs studied.

These Heape divided into eight groups, according to his classification of the endometrial cycle. It would appear from his descriptions that 18 animals

* The opposite view, that monkeys and apes have breeding-seasons, coupled with the fact that statistical studies reveal a seasonal variation in the human conceptility rate, has in certain places led to the belief that sometime in the early history of man there existed a pairing season, the vestiges of which are represented by the periodic erotic feasts held by many peoples. (See, for instance, Westermarck (1921) and Heape (1900).) This possibility is very remote. There are, moreover, enough cultural and economic factors to which to ascribe seasonal variations in the human birth rate before appealing for an explanation to the scanty information that is available regarding the breeding habits of most Old World monkeys and apes.

were in the pre-ovulation phase of the cycle; 12 in stage 8, the period of recuperation; and six in stage 1, the period of rest. In none of these was there a discharged follicle, but he found "prominent follicles" in seven. The period of growth, stages 2 and 3, accounted for 10 animals. Five of these showed "prominent" ovarian follicles; in four nothing was visible on the surface of the ovaries, and one, according to his 1894 paper, showed a "red corpus luteum"—the sign of a recently-discharged follicle. In 1897, however, he stated, after examination of the sectioned ovary, that this was incorrect, and that no corpus luteum was present. The period of degeneration, stages 4 to 7, was represented by 20 specimens. In stages 6 and 7 he found four specimens with "prominent" follicles. In stage 4 he found one that had a "large pendent corpus luteum on the right ovary." In his 1897 paper, however, he corrects this statement, remarking that section failed to show a corpus luteum. One of this group had an "old corpus luteum in the left ovary," and five had "somewhat prominent" vesicles.

These ovarian findings are extraordinary in view of the fact that the recent work of American experimentalists has definitely established that there is no phase of pre-menstrual growth of the uterine mucosa in cycles without ovulation. Such growth is dependent on the formation of a corpus luteum. If there is no corpus luteum—if ovulation has not occurred—menstruation takes place from an "interval" endometrium, which, from Heape's description, seems the same as his "period of rest." The statement that "not a single one of the 42" menstruating monkeys had ovulated would seem to be incompatible with his statement that ten of them were showing signs of premenstrual growth. Either his ovarian observations were fallacious, or his empirical classification of the stages of the uterine cycle is misleading. Moreover, if one agrees with his interpretation, it would be necessary to believe that every one of the 16 "prominent" follicles that he found were becoming atretic, a view for which he provides no evidence. The finding of these follicles, too, conflicts with Hartman's experimental observation that the ovaries in cycles without ovulation are inactive. All this makes it somewhat difficult to estimate the value of such of Heape's opinions about the breeding of the *Entellus Langur* as were based on his anatomical observations. One encounters the same difficulty in the consideration of his *Rhesus Macaque* data (1897).

Van Herwerden's view that the Common Macaque has a seasonal variation in fertility (1905) is also open to criticism. She found that 60 non-pregnant uteri in the Utrecht Collection fell into two groups. The small uteri with low endometria of the first group were mostly associated with inactive ovaries. The big uteri with high endometria of the second group were associated with ovaries containing either prominent follicles or corpora lutea. Having briefly considered, and rejected, the possibility that the uteri of the first group were from young, menopausal, and lactating females, she suggested that they had been taken from the females killed during a yearly season of lowered fertility, while those of the second group were taken in a fertile season. To support her belief in the existence of these seasons, she states that conception had probably occurred some time in the period August to October in the case of twenty of thirty pregnant Common Macaque uteri in the same collection. Without, however, being told what proportion of the total number of uteri collected in each month of the year were pregnant, it is difficult to decide whether this fact is really suggestive of a season of higher fertility. Clearly Van Herwerden's view that the two groups of uteri were collected in different seasons is mainly speculative.

In the same paper, and also in a paper devoted to a discussion of the breeding of monkeys (1925), Van Herwerden provides a frequency curve that indicates clearly that *Tarsius spectrum* breeds at all times of the year.

The data used in the construction of this curve are derived from the Utrecht collection of more than 1000 uteri and ovaries of *Tarsius* collected by Hubrecht in the Island of Banka. The curve is constructed from the absolute number of pregnant females taken each month, and it shows that most of the pregnant uteri in the collection were taken in October and November at the end of the dry season, though some were taken in every month. Van Herwerden interprets the curve as indicating that *Tarsius* has an "inclination to a higher productivity in special oestrous cycles."

It is quite possible that this is so. The curve, however, does not prove it. For, seeing that it was constructed from absolute numbers, and not from percentages pregnant each month, it is obvious that what it may chiefly indicate is that animal collectors are more active in Banka in dry and fine weather than in the rainy season.

At present, therefore, it would seem that there are no data available to show whether or not the conclusion Hartman draws from his experimental data and breeding records—that the Rhesus Monkey has a tendency towards ovarian inactivity between May and August—is applicable to monkeys in their wild state. Before the question can be considered settled, it is essential that further studies should be made on new and accurately documented material collected in the wild.

6. CONCLUSIONS.

The facts recorded in this paper prove conclusively that the Chacma Baboon of the Eastern Province of South Africa has no demarcated breeding-season in its wild state. The same is probably true of the Chacma Baboon living in other parts of the country. Little is known in regard to the breeding of other Old World Primates, but the available evidence suggests that they, too, can become pregnant at all times.

7. SUMMARY.

(1) During March, April, and May of 1930 observations were made in South Africa on the Chacma Baboon (*Papio porcarius*).

(2) Baboon packs, in which were nursing females as well as females with sexual skin swelling, were seen in the Eastern and Western Provinces.

(3) On May 4th twelve females belonging to the same pack were killed near Grahamstown, in the Eastern Province. Four were non-pregnant: one of these was menstruating, one was in the pre-ovulation, and two in the post-ovulation phase of the cycle. Five were pregnant: the first of these had an embryo 2.5 mm. in length, the second one of 16.5 mm., the third one of 19 mm., the fourth one of 65 mm., and the fifth an apparently full-term male foetus with a crown-rump length of 230 mm. Three were lactating, and their babies were caught alive.

(4) Data are provided regarding the times of milk-tooth eruption in baboons, indicating that two of the babies were about two months old and the third about four months.

(5) A complete reproductive cycle in the baboon—the shortest interval of time between two births by the same female—is approximately a year. The females shot on May 4th were representative of practically all stages of the cycle.

(6) This proves that the Chacma Baboon has no demarcated breeding-season, but that it can give birth at any time of the year.

(7) The question of the breeding of other Old World primates is discussed. Records of monkey births in captivity indicate that most Old World primates can conceive at any time.

(8) The possibility that there exists a seasonal variation in the monkey's conceptility rate does not conflict with the underlying fact that the baboon, and probably most other Old World primates, has no demarcated breeding-season. There is a fundamental distinction between mammals with a fixed œnestrus, like the ferret, and mammals like the baboon that have no œnestrus.

Leave of absence to visit South Africa in order to collect the data recorded in Section 3 of this paper was very kindly given me by the Council of the Zoological Society and by the authorities of University College, London. My expenses were defrayed by grants given by the Council of the Royal Society of London and by the Council of the Zoological Society. In South Africa I was very fortunate in securing the help of many interested people, of whom I would especially mention Mr. John Hewitt, the Curator of the Albany Museum, Grahamstown, and Captain G. C. Shortridge, the Curator of the Kaffrarian Museum, King William's Town.

I also wish to acknowledge the stimulating interest shown by Professor G. Elliot Smith, F.R.S., in this work, and that of Professor J. P. Hill, F.R.S., to whom I am also indebted for advice regarding the embryos mentioned in Section 3 (A).

8. BIBLIOGRAPHY.

- ALVERDES, FR. 1927. *Social Life in the Animal World*. Kegan Paul, Trench, Trubner & Co. Ltd., London.
- BAKER, J. R. 1930. The Breeding-Season in British Wild Mice. *Proc. Zool. Soc. London*, pp. 113-126.
- FLOWER, S. S. 1929. *Vertebrate List*. Vol. i.—Mammals. Zoological Society, London.
- FORBES, H. O. 1894. *Handbook to the Primates*. Allen, London.
- H., C. 1880. *Sketches of Natural History at Gibraltar*. The Field, London, p. 79.
- HARTMAN, C. 1929. A Breeding and a Non-Breeding Season in the Monkey, *Macacus rhesus*. *Anat. Rec.*, Philadelphia, vol. xlv. p. 226. (Abstract.)
- HEAPE, W. 1894. The Menstruation of *Semnopithecus entellus*. *Phil. Trans. Roy. Soc. London*, B, vol. clxxxv. pp. 411-471.
- 1897. The Menstruation and Ovulation of *Macacus rhesus*, with Observations on the Changes undergone by the Discharged Follicle.—Part II. *Phil. Trans. Roy. Soc. London*, B, vol. clxxxviii. pp. 135-166.
- 1900. The "Sexual Season" of Mammals and the Relation of the "Pro-œstrum" to Menstruation. *Quart. Journ. Micros. Sci.*, London, vol. xlv. pp. 1-70.
- HILL, M., & PARKES, A. S. 1930. The Relation between the Anterior Pituitary Body and the Gonads.—Part II. The Induction of Ovulation in the Aœnestrus Ferret. *Proc. Roy. Soc. London*, B, vol. cvii. pp. 30-49.
- JOACHIMOVITS, R. 1928. Studien zu Menstruation, Ovulation, Aufbau und Pathologie des weiblichen Genitales bei Mensch und Affe (*Pithecius fuscicularis mordax*). *Biologia Generalis*, Vienna, vol. iv. pp. 447-540.
- KENDREW, W. G. 1927. *The Climates of the Continents*. Oxford.
- LOVEBRIDGE, A. 1923. Notes on East African Mammals. *Proc. Zool. Soc. London*, pp. 695-799.
- LYDEKKER, R. 1895. *Handbook of the British Mammalia*. W. H. Allen & Co., London.
- MARSHALL, F. 1922. *The Physiology of Reproduction*. Longmans, Green & Co., London. 2nd edition.
- NICOLLE, C., et WETTERLÉ, L. 1930. A propos de trois naissances dans la singerie de l'Institut Pasteur de Tunis. *Bull. Soc. Path. Exot. Paris*, tome xxiii. pp. 596-599.

- PARKES, A. S., & ZUCKERMAN, S. 1931. The Menstrual Cycle of the Primates.—Part II. Some Effects of Estrin on Baboons and Macaques. *Journ. Anat., Cambridge*, vol. lrv. pp. 272-276.
- ROWLEY, J. 1929. Life-History of the Sea-Lions on the California Coast. *Journ. Mamm., Baltimore*, vol. x. pp. 1-36.
- SCHUSTER, L. 1929. Ein Beitrag zur Frage der Brunst- und Setzzeiten der Säugetiere in den Tropen. *Zool. Garten, Leipzig*, vol. ii. pp. 114-117.
- SCLATER, P. L. 1900. On the *Macacus inuus* of Gibraltar. *Proc. Zool. Soc. London*, p. 773.
- SCLATER, W. L., & SCLATER, P. L. 1899. The Geography of Mammals. Kegan Paul, London.
- SETON, E. T. 1910. Life-Histories of Northern Animals. Vol. i.—Grass-eaters. Constable, London.
- SPIEGEL, A. 1929. Biologische Beobachtungen an Javamakaken, *Macacus irus* F. Cuv. (*cynomolgus* L.). *Zool. Anz.* vol. lxxxi. pp. 45-65.
- 1930. Beobachtungen über den Sexualzyklus, die Gravidität und die Geburt bei Javamakaken (*Macaca irus mordax* Thomas & Wroughton (*cynomolgus* L.)). *Arch. Gynäk., Berlin*, vol. cxlii. pp. 561-591.
- STEVENSON-HAMILTON, J. 1912. Animal Life in Africa. William Heinemann, London.
- STRUTHERS, P. H. 1928. Breeding-Habits of the Canadian Porcupine (*Erethizon dorsatum*). *Journ. Mamm., Baltimore*, vol. ix. pp. 300-308.
- VAN HERWERDEN, M. 1905. Bijdrage tot de Kennis van Menstrueelen Cyclus en Puerperium. Brill, Leiden.
- 1925. Some Remarks on the Polycæstrus of Primates. *Anat. Rec., Philadelphia*, vol. xxx. pp. 221-223.
- WESTERMARCK, E. 1921. The History of Human Marriage. 5th edition. Macmillan, London.
- ZUCKERMAN, S. 1930. The Menstrual Cycle of the Primates.—Part I. General Nature and Homology. *Proc. Zool. Soc. London*, pp. 691-754.

16. Note on a new Species of Dinoflagellate from the Gills and Epidermis of Marine Fishes. By ELEANOR M. BROWN, B.Sc., Aquarium Research Fellow.

[Received March 16, 1931 : Read March 17, 1931.]

The object of this note is to establish the identity of a new species of Dinoflagellate which is found on the gills and epidermis of a number of warm water marine fishes in the Society's Aquarium. It is the cause of heavy mortality among fishes imported annually from Bermuda, and also among the Coral Fish *Amphiprion percula*.

The organism in its adult vegetative stage is a spherical or oval, colourless, unicellular cyst. Its average diameter is $70\ \mu$, but all sizes varying from $20\ \mu$ upwards have been observed. The smaller forms tend to be oval and even pear-shaped, while the larger forms are spherical. The pear-shaped smaller cysts are attached to the gills of the fish by the narrow end, which is drawn out in the form of a stalk. As the cyst increases in size and becomes spherical, the attachment to the gills becomes very attenuated and is sharply marked off from the main body of the cyst. At this stage the cysts are very caducous, and it is only rarely that the mode of attachment to the host is seen.

The cysts on attaining their maximum development, and quite frequently earlier, fall from the fish. At this stage some are seen to be spherical, showing no sign of their attachment to their host, while others are somewhat disc-shaped and exhibit an indentation at one end, which gives them a heart-shaped appearance. Both attached and unattached cysts show the same structure in the living state. They consist of a single cell with finely granular cytoplasm, and a vesicular nucleus round which a number of refringent granules are grouped. The cell is surrounded by a thin, colourless membrane. An elongated red eyespot is visible in some specimens, but is difficult to observe owing to the density of the cell contents. Chromatophores are absent.

Under suitable conditions detached cysts divide into two equal parts, each resembling the parent cell. The two parts are enclosed in a common membrane, but each daughter cell now secretes a membrane round itself. Division is repeated, giving rise to 4, 8, 16, 64, and 128 cells, which remain enclosed in the original envelope, though as before, each new product of division secretes a new membrane. During division the refringent granules pass into the daughter cells without division so that their number is reduced at each successive division. Division of the cells is preceded by division of the nucleus, and there is no period of growth between the various divisions. The eyespot becomes more and more marked as division proceeds, and the cell contents become less opaque.

From one set of observations it appears that the division subsequent to the 128-cell stage results in the formation of products unlike the parent cell. Each cell divides to form two dinospores which begin to move within the membrane and finally burst through it and swim away. The two spores are at first attached to each other at the anterior end, but soon become free and swim about rapidly with a typical dinoflagellate movement. The dinospores examined were approximately $12\ \mu$ in length and closely resembled in general appearance those described by Pouchet and Chatton for *Oodinium poucheti*.

They were naked and showed the two flagella typical of the group, a transverse flagellum situated in a well-marked girdle and a backwardly directed longitudinal flagellum which was not contained in a well-marked sulcus. An eyespot was present in the neighbourhood of the longitudinal flagellum. These spores, it is assumed, give rise to the vegetative form when they settle on a fish.

From this summary it appears that the organism has affinities with the group of parasitic dinoflagellates described by Chatton (1) and that the genus *Oodinium* (Chatton) is most nearly related to it. This genus consists of a number of species attached to the external surface of various pelagic animals, such as Appendicularians, Salps, and Polychæts. No parasitic dinoflagellate has as yet been described from a craniate vertebrate and this species differs from all the known forms of *Oodinium* in several ways. The genus is described by Chatton as containing a number of forms whose evolution is as yet incompletely known and having the following characteristics: "Leur corps fixé à l'état végétatif, de grande taille (150-200 μ) ovoïde ou sphérique, sans sillons ni flagelle à cuticule bien individualisée, à noyau volumineux vésiculeux. Leur appareil de fixation, tronc court robuste à structure fibrillaire retractile ou caduc, qui leur permet de se libérer. Leur reproduction par dinospores nombreuses résultant de segmentation égales et répétées du corps à l'état libre. Tous caractères d'adaptation au parasitisme qui les différencient nettement du type du genre *Gymnodinium* (Stein), le *Gymnodinium fuscum* (Ehrbg.), forme libre."

The present species differs from all other members of the genus in the possession of an eyespot and its somewhat smaller size. The mode of division is essentially similar, but the products of division remain enclosed in a common envelope and do not separate after each division, as in the other species in which sporulation is known. More detailed knowledge of the structure and mode of attachment of the peduncle is necessary in determining the affinities of the organism exactly. It seems clear, however, from the young form, that the attachment is a prolongation of the living cell and not a non-cellular secretion.

It is therefore proposed provisionally to refer the organism to the genus *Oodinium* pending a more detailed cytological examination of the structure. In view of its marked differences from the described species, it is referred to a new species—*Oodinium ocellatum*, with the following characteristics:—

Oodinium ocellatum on the skin and gills of marine fishes *Holocentrus ascensionis*, *Amphiprion percula*, and others. Vegetative stage a colourless unicellular cyst, pear-shaped in the early stages, and attached by the narrow end. Spherical in later stages and attached by a short stalk. Diameter varying from 20-70 μ . Vesicular nucleus with large endosome. Cytoplasm containing refringent granules grouped round the nucleus. Eyespot present. Dinospores resulting from equal and repeated division of the body, resembling those of *Oodinium poucheti*, but with an eyespot near the posterior flagellum. Dinospores 12 μ in length.

A paper is in the course of preparation dealing with the occurrence of this organism in the Aquarium, its effect on the fishes, the conditions under which it flourishes, and attempts to eradicate it. Further investigations into the cytological structure of the adult and sporulating individuals, and a more detailed consideration of its systematic position will be included.

REFERENCE.

- CHATTON, E. Les Péridiniens Parasites. Arch. de Zool. Expér. et Générale, t. 59, pp. 1-475, March 1920.

EXHIBITIONS AND NOTICES.

February 3rd, 1931.

Prof. E. W. MACBRIDE, M.A., F.R.S., Vice-President, in the Chair.

Dr. G. M. VEVERS, F.Z.S., read the following Report on the Additions to the Society's Menagerie during the months of November and December 1930 :—

NOVEMBER.

The registered additions to the Society's Menagerie during the month of November were 110 in number. Of these 66 were acquired by presentation, 18 were purchased, 5 were deposited, 3 were received in exchange, and 18 were born in the Menagerie.

The following may be specially mentioned :—

A Pigmy Hippopotamus (*Chæropsis liberiensis*), ♂, born in the Menagerie on November 1st.

An Anoa (*Anoa depressicornis*), ♀, born in the Menagerie on November 5th.

7 Secretary-Birds (*Sagittarius serpentarius*), from South Africa, purchased on November 7th.

5 Harris Sparrows (*Zonotrichia querula*), from Canada, new to the Collection, presented by Prof. Wm. Rowan on November 23rd.

2 Palawan Peacock-Pheasants (*Polyplectron napoleonis*), from the Island of Palawan, new to the Collection, received in exchange on November 25th.

DECEMBER.

The registered additions to the Society's Menagerie during the month of December were 50 in number. Of these 28 were acquired by presentation, 6 were purchased, 10 were deposited, 2 were received in exchange, and 4 were born in the Menagerie.

The following may be specially mentioned :—

A Pudu Deer (*Pudu puda*), born in the Menagerie on December 4th.

A Feather-tailed Phalanger (*Distachurus pennatus*), new to the Collection, from New Guinea, presented by A. St. Alban Smith, Esq., F.Z.S., on December 22nd.

A Loo Choo Jay (*Lalocitta lidghi*) and two Sæmmerring's Pheasants (*Syrnaticus sæmmerringi*), from Japan, purchased on December 1st.

Mr. G. C. ROBSON, M.A., F.Z.S., exhibited, and made remarks upon, the remarkable Cephalopod, *Cirrothauma murrayi*.

Mr. J. R. NORMAN, F.Z.S., exhibited, and made remarks upon, a photograph of an abnormal Eel (*Anguilla anguilla* Linn.).

Mr. E. G. BOULENGER, F.Z.S., exhibited, and made remarks upon, an abnormal specimen of a Turbot (*Rhombus maximus*).

Mr. D. SETH-SMITH, F.Z.S., exhibited, and made remarks upon, a Diary of Wild Life observed at Whipsnade.

Dr. S. ZUCKERMAN, M.A., M.R.C.S., L.R.C.P., exhibited, and made remarks upon, a series of preparations of Primate Mammary Glands.

February 17th, 1931.

Sir ARTHUR SMITH WOODWARD, F.R.S., Vice-President, in the Chair.

The SECRETARY read the following Report on the Additions to the Society's Menagerie during the month of January 1931 :—

The registered additions to the Society's Menagerie during the month of January were 65 in number. Of these 38 were acquired by presentation, 22 were purchased, 3 were deposited, and 2 were born in the Menagerie.

The following may be specially mentioned :—

A Chimpanzee ♀ (*Pan satyrus*) from West Africa, presented by Arthur Haserick, Esq., F.Z.S., on January 1st.

A Lion cub ♀ (*Felis leo*) from South Africa, presented by Mrs. J. Stevenson-Hamilton, on January 5th.

2 Fishing Cats (*Felis viverrina*) from South-east Asia, presented by A. St. Alban Smith, Esq., F.Z.S., on January 16th.

3 Llamas ♂ ♂ ♀ (*Lama glama*) bred in Bedfordshire, presented by A. H. Wingfield, Esq., D.L., F.Z.S., on January 23rd.

3 Amboina King-Parakeets (*Aprosmictus amboinensis*) from Amboina and two White-rumped Lorries (*Eos fuscata*) from New Guinea, presented by A. St. Alban Smith, Esq., on January 16th.

2 Manchurian Cranes (*Megalornis japonensis*), presented by W. H. St. Quintin, Esq., F.Z.S., on January 28th.

Prof. G. ELLIOT SMITH, F.R.S., F.Z.S., exhibited, and made remarks upon, a series of casts and photographs of the bones of the Peking Skull (*Sinanthropus*).

Prof. RAYMOND DART exhibited, and made remarks upon, the actual fossil remains of *Australopithecus*.

March 3rd, 1931.

Prof. E. W. MACBEIDE, M.A., F.R.S., Vice-President, in the Chair.

Major S. S. FLOWER, O.B.E., F.Z.S., exhibited a piece of wire and stated that instances of mice (or rats) interfering with electric current are not

unknown. Cases reported refer to old houses newly wired for electricity, where the general disturbance may have upset the routine of murine life or the novelty excited the curiosity of the animals.

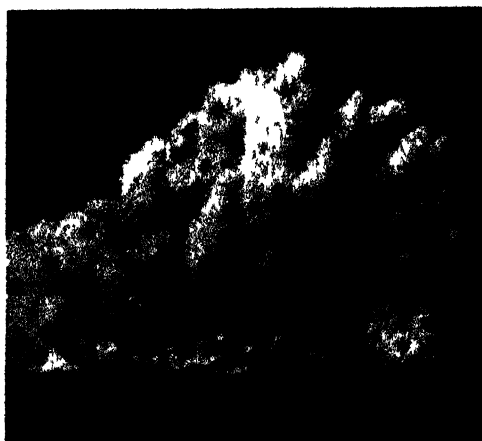
Owing to the economic importance of the question, a definite instance was worth recording.

An old house, near Tring, was wired for electricity in 1924 and a 100 volt direct current used. In 1930 this was changed to a 220 volt alternating current. Some days later the lights failed in part of the house, the cause being that a wire had been gnawed by mice.

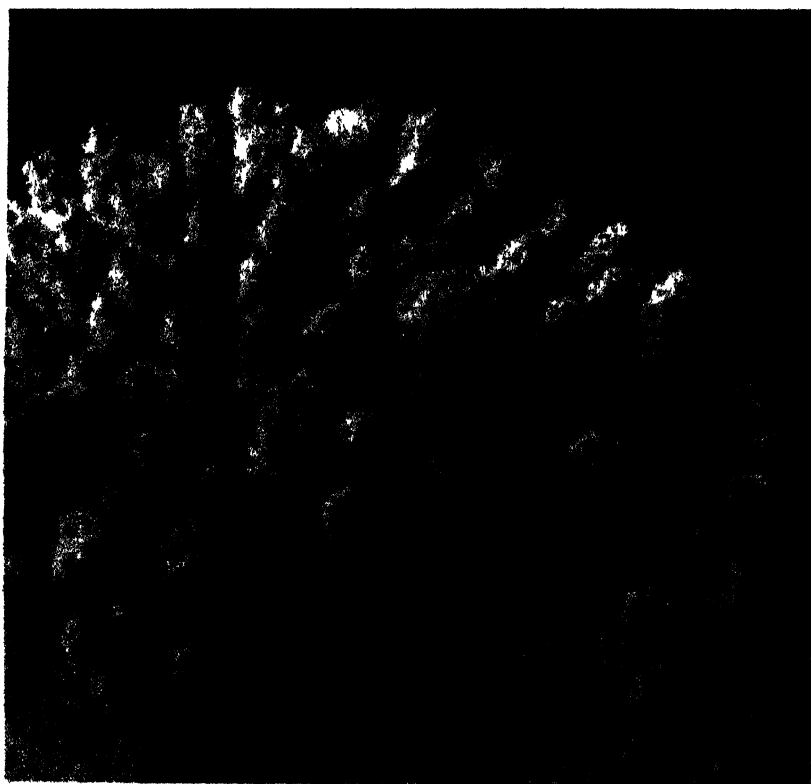
The question was why the mice had left the wire alone for 5½ years, and then attacked it when a direct current had been replaced by an alternating one.

The mouse concerned was the House-Mouse, *Mus musculus*.

[Proceedings, 1930, Part IV. (pp. 849-1080), was published on
January 21st, 1931.]

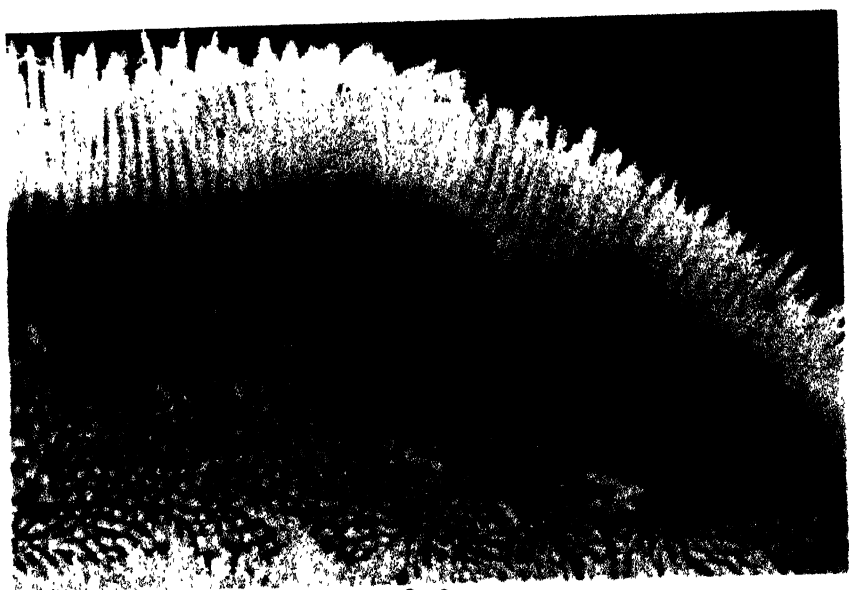


1x2

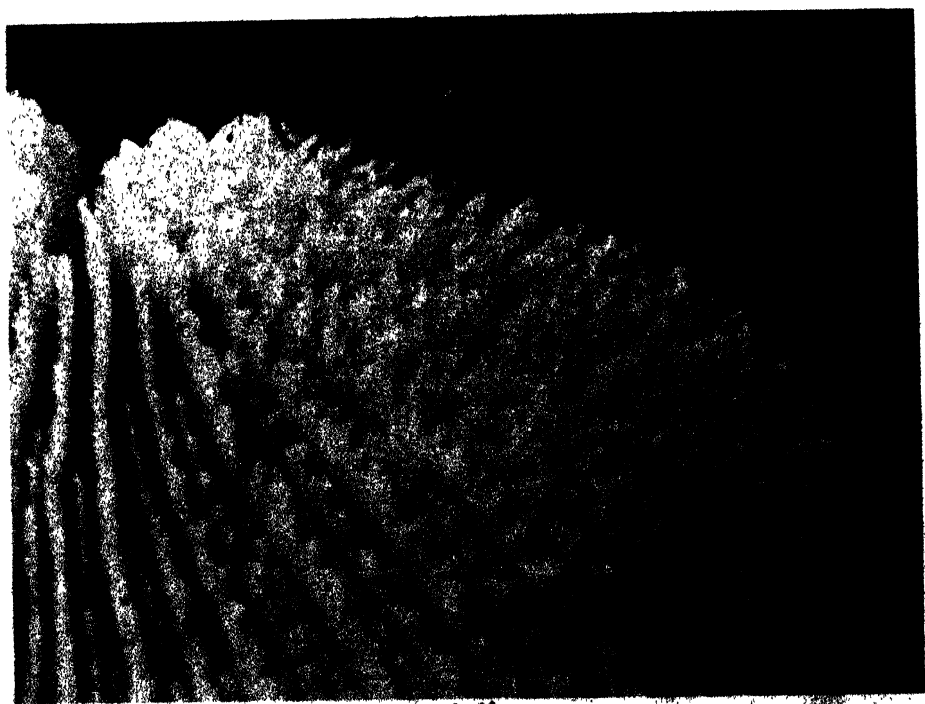


2x1

(1) *Cyphastrea* and (2) *Leptastrea* sp. with *Phyllochoelopterus*.

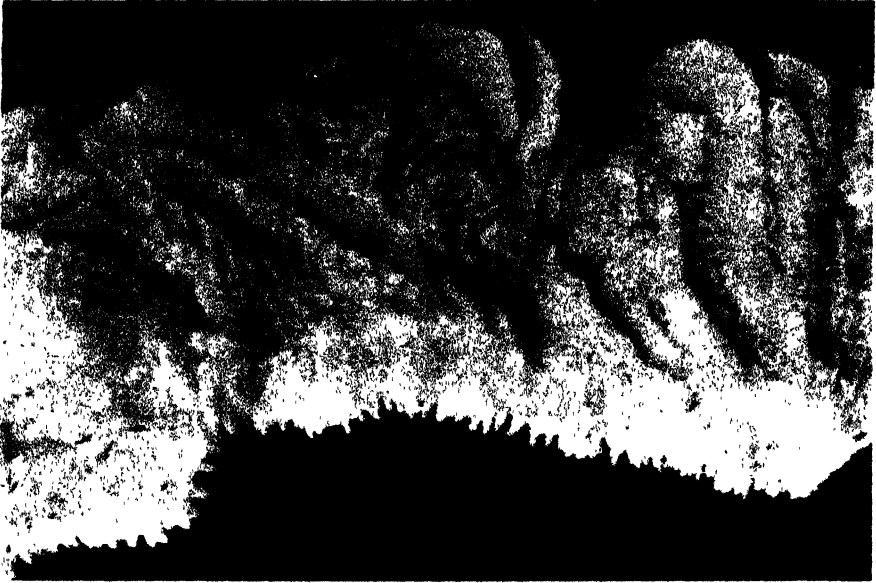


3 x 2



4 x 12

(3) *Herpetolites* and (4) *Fungia*.

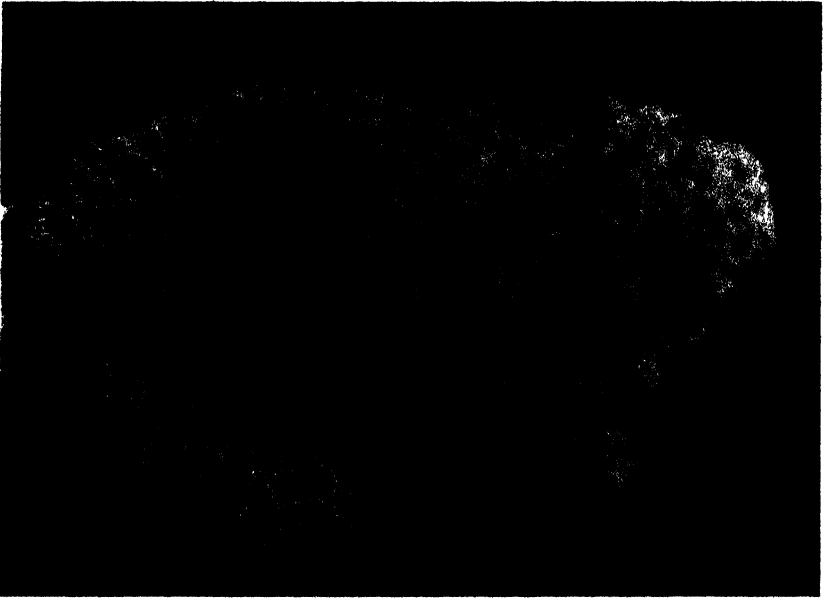


5 x 2



6 x 2

(5-6) *Herpetolitha limax*.

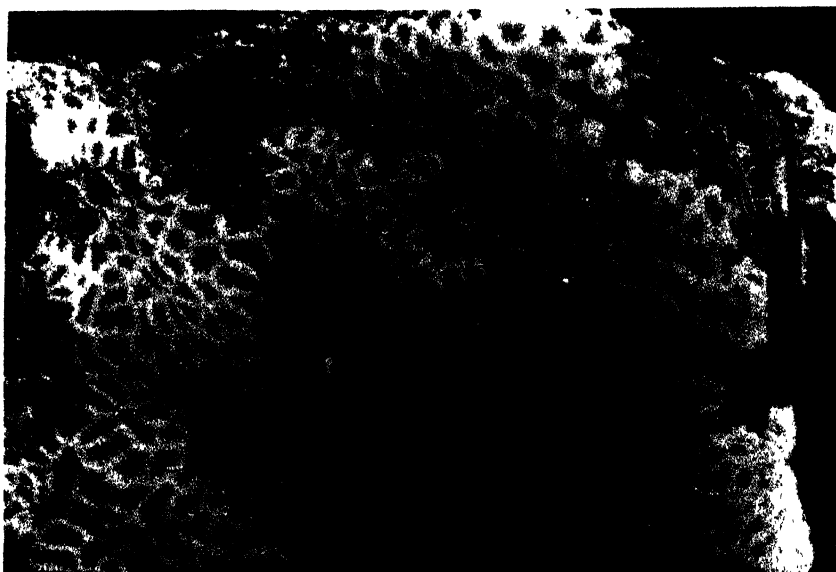


7x2

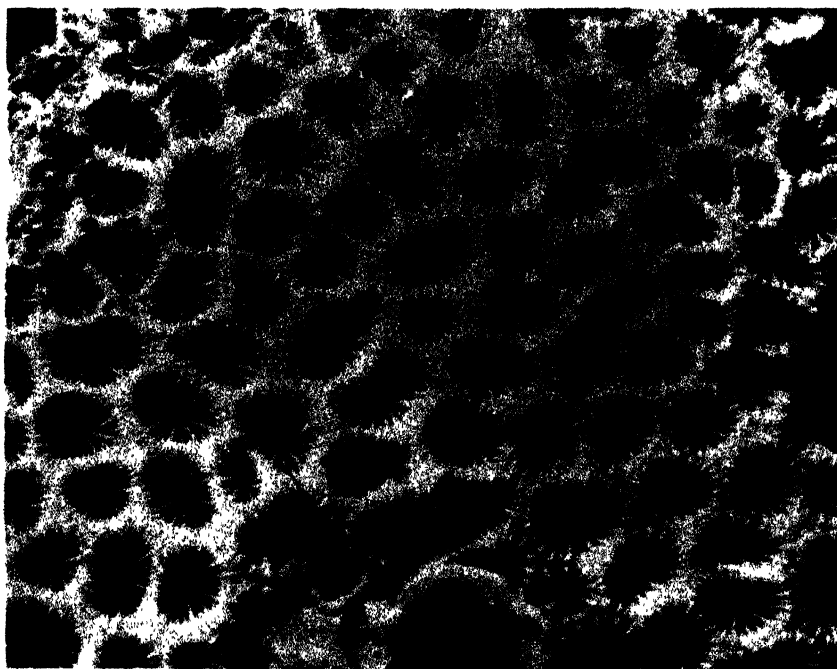


8x4½

(7-8) *Cyphastrea microphthalmia*.

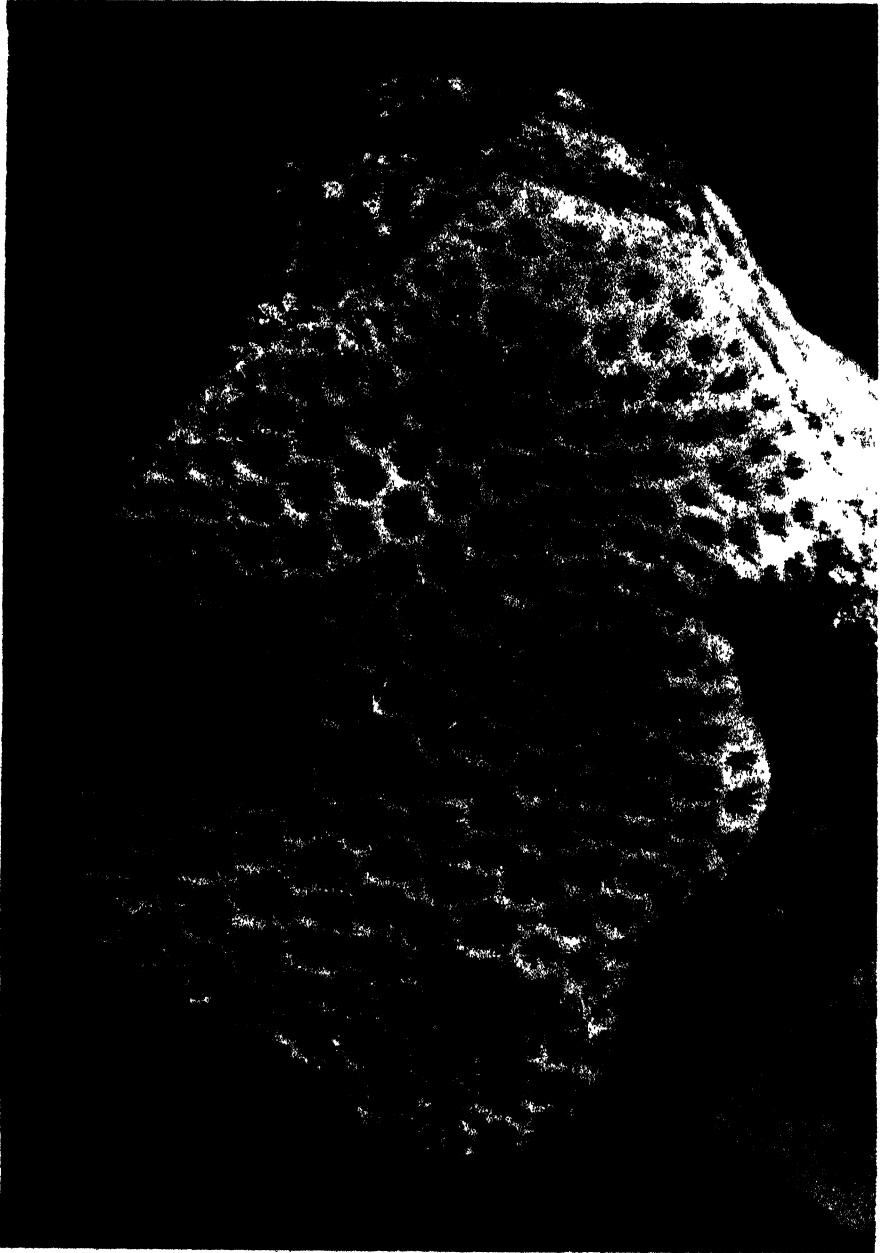


9 x 1



10 x 4

(9-10) *Leptastrea*.



11 × 2

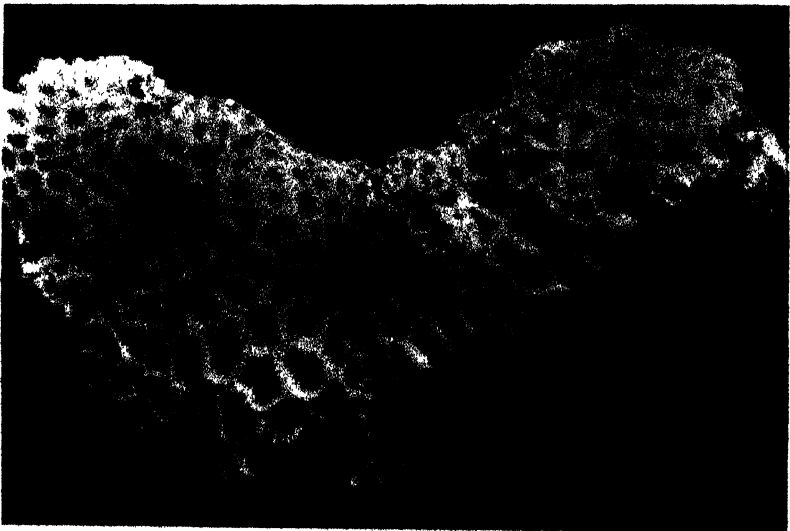
(11) *Leptastrea*.



12 x 1

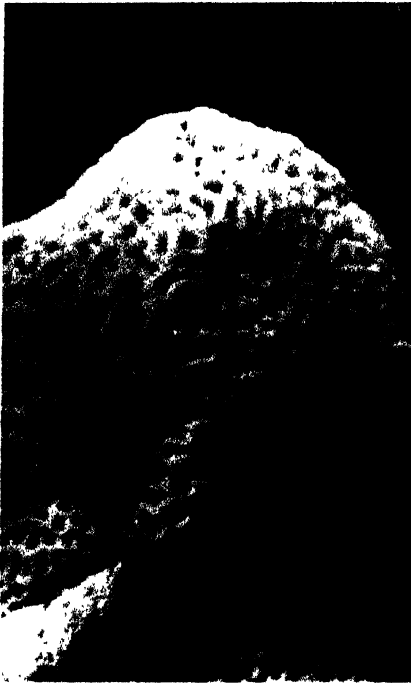


13 x 1

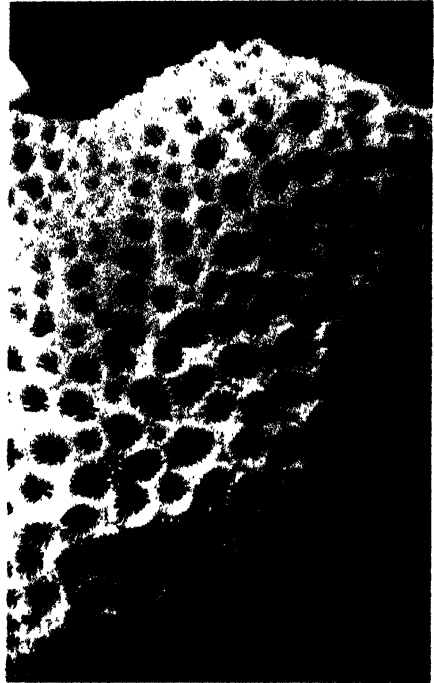


14 x 1

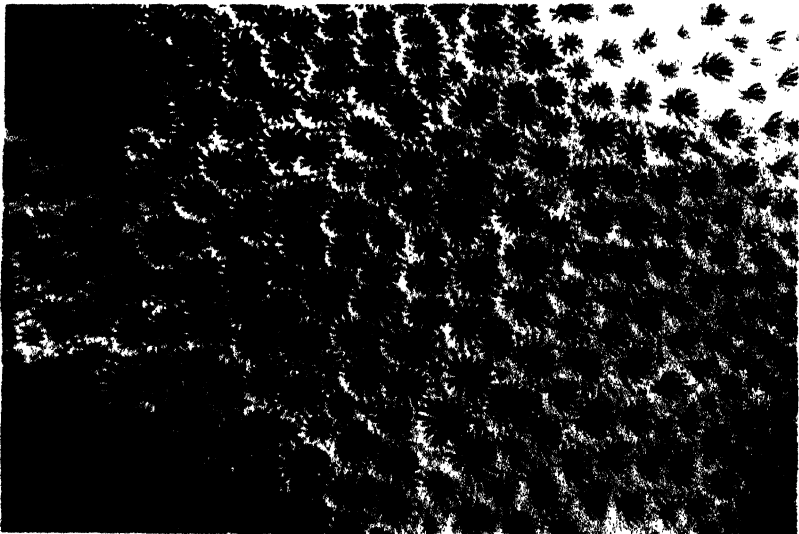
(12-13-14) *Leptastrea*.



15 × 8

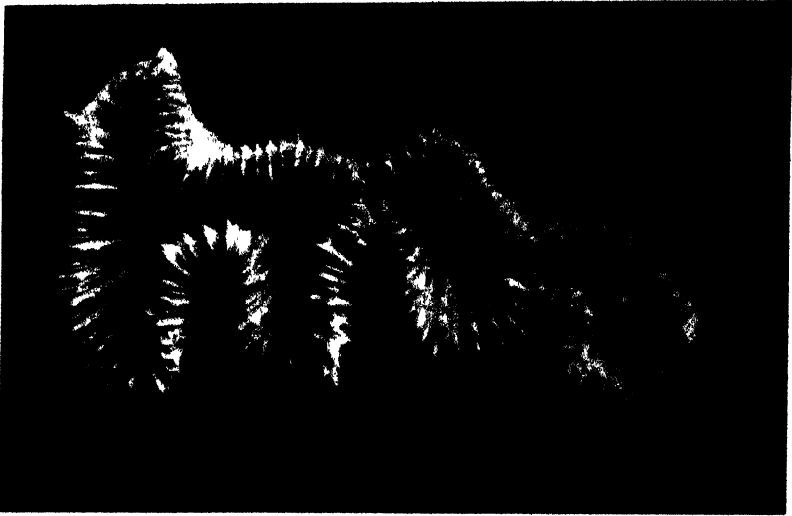


16 × 13

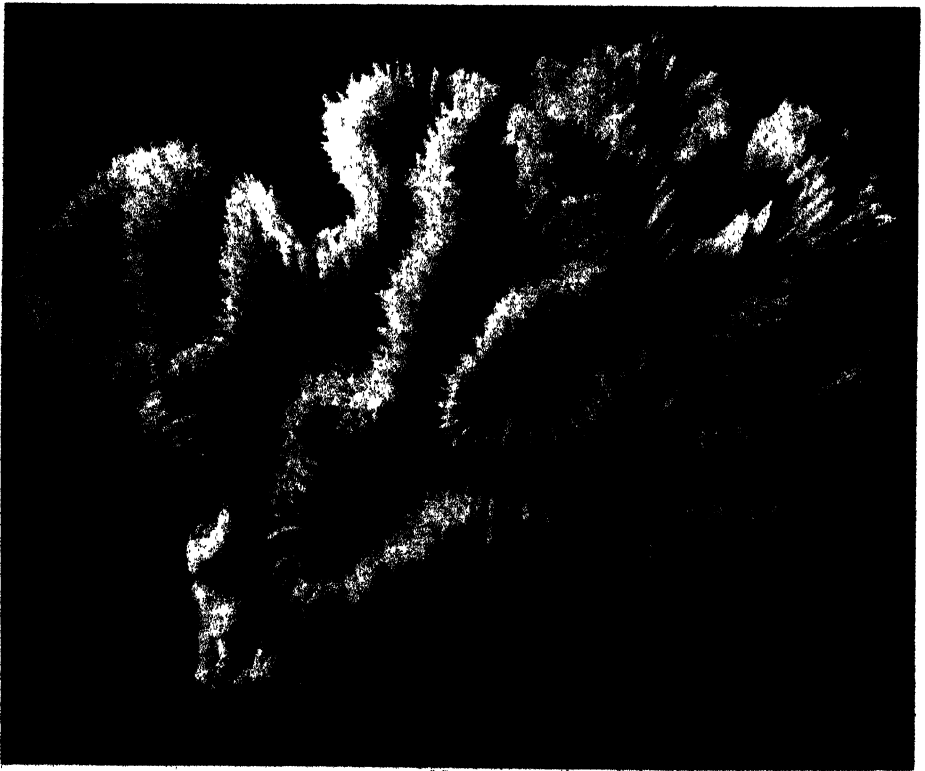


17 × 2

(15-16-17) *Leptastrea*.



18 x 1



19 x 1

(18-19) *Lobophyllia*.



20 $\times \frac{1}{2}$

21 $\times \frac{1}{2}$

(20) *L. corymbosa-costata*. (21) *L. corymbosa*.



22x1

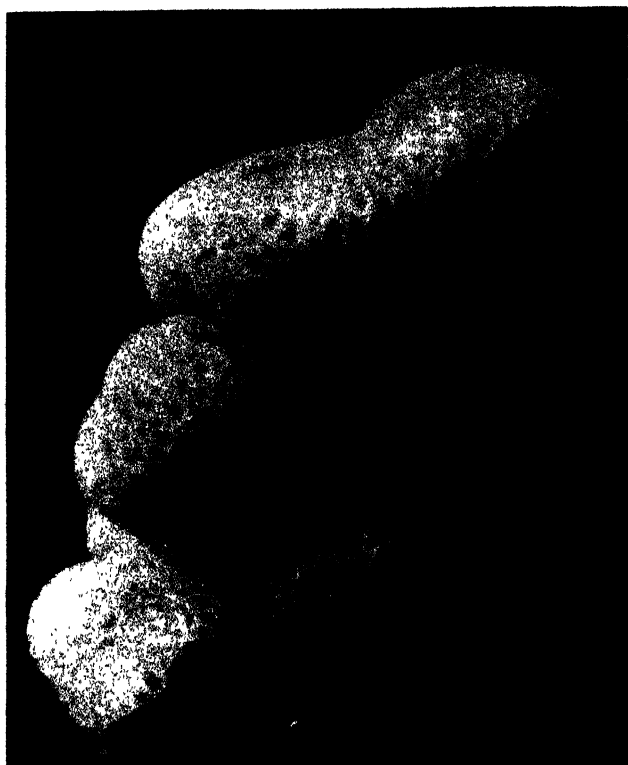
(22) *Lobophyllia* form *cytherea*.



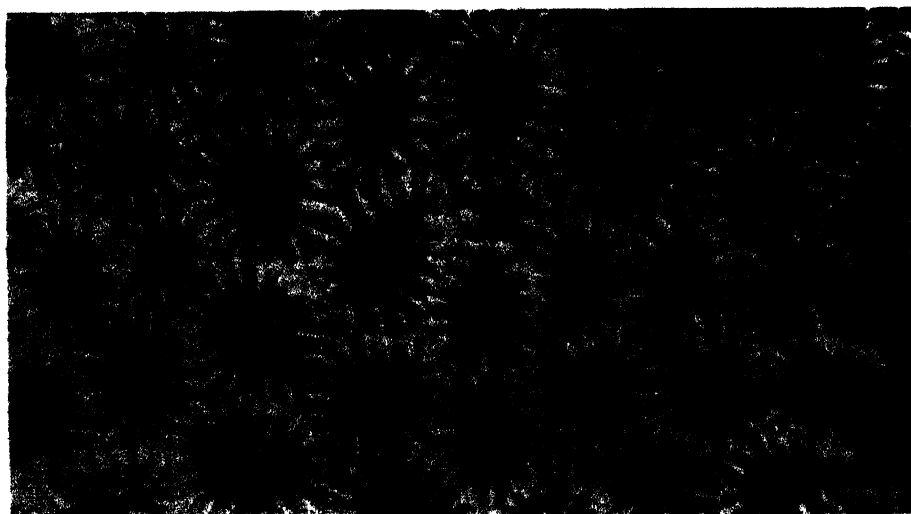
23 x $\frac{2}{8}$

24 x 1

(23) *L. corymbosa*. (24) *L. form cytherea*.



25 x 1



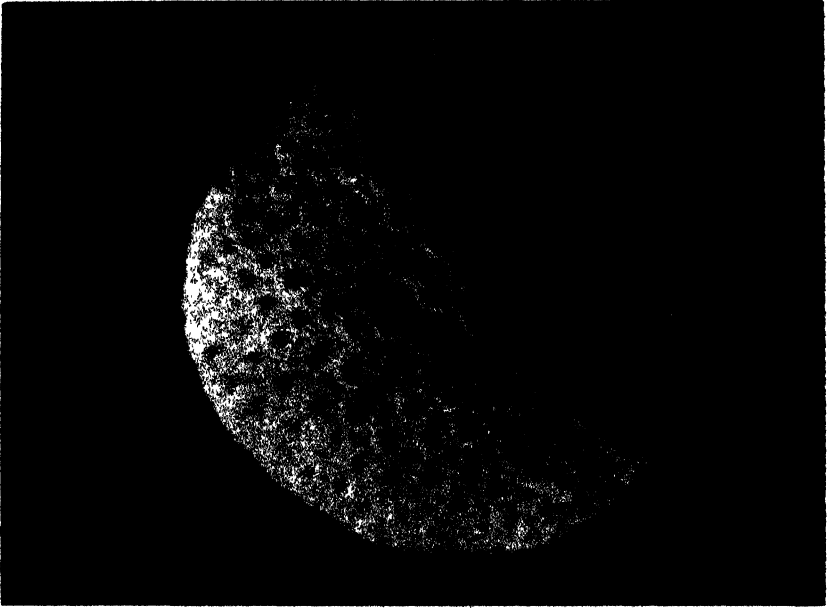
26 x 5

(25-26) *Favia stelligera*.

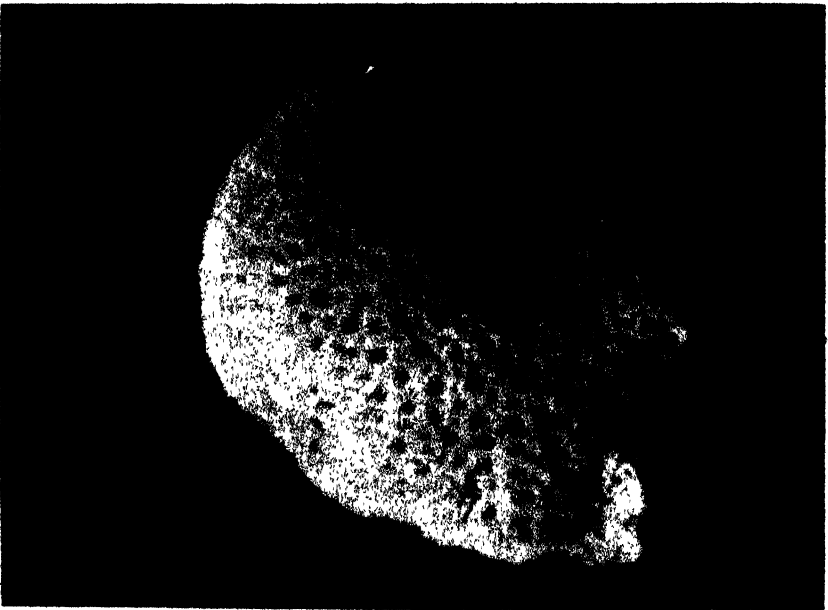


27 x2

(27) *Favia stelligera*.

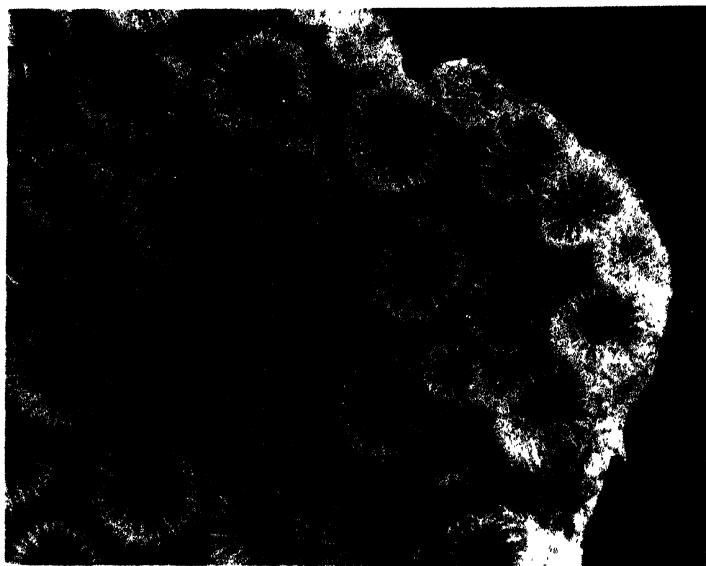


28

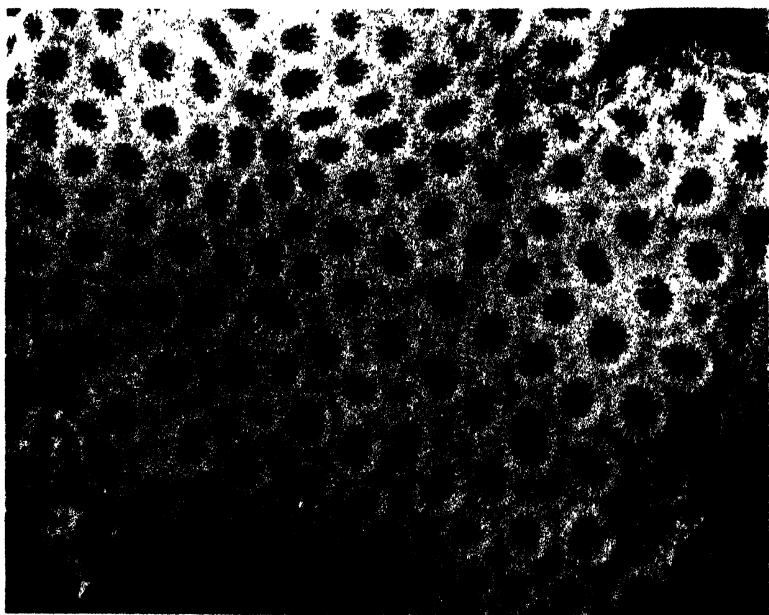


29

(28-29) *Fuvia curta-solidior*. (slightly under nat. size)

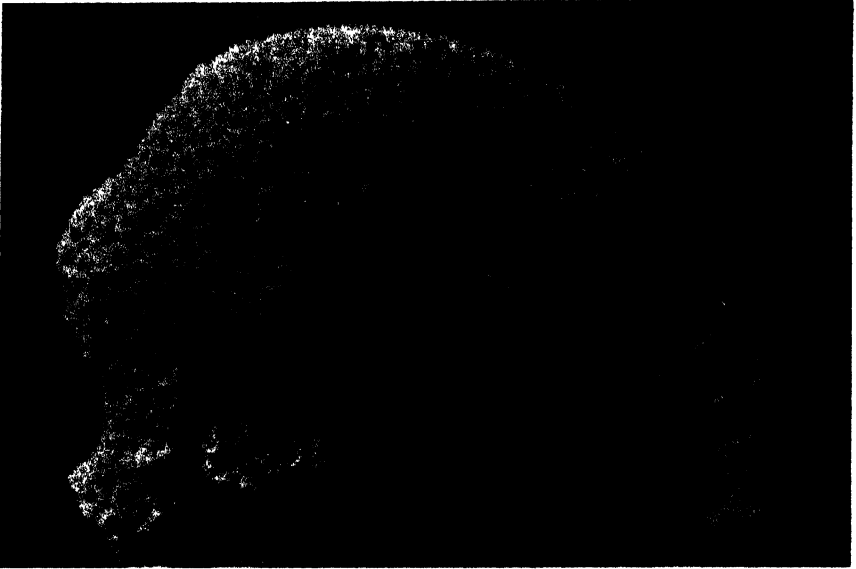


30x2

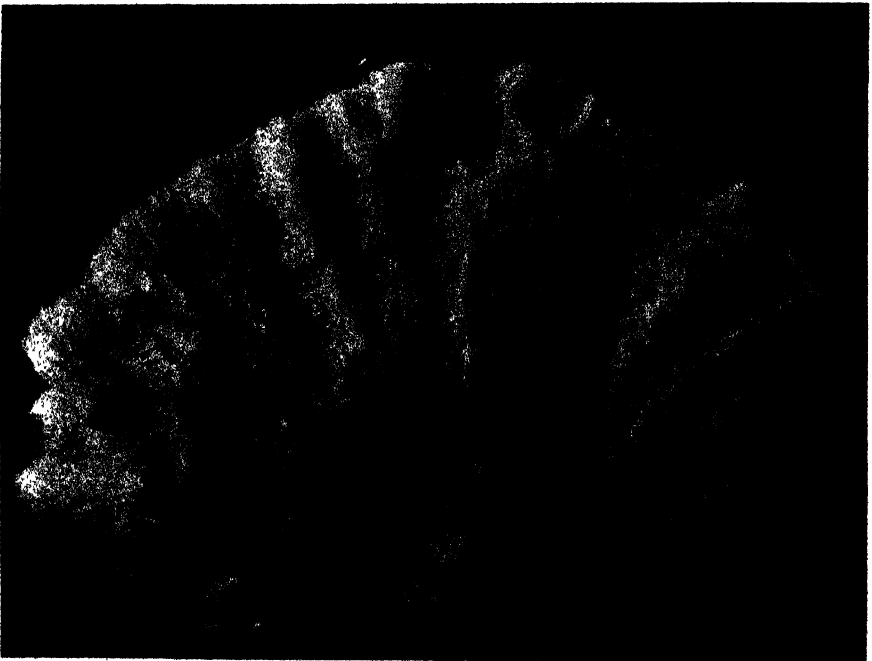


31x1½

(30-31) *Favia versipora*.

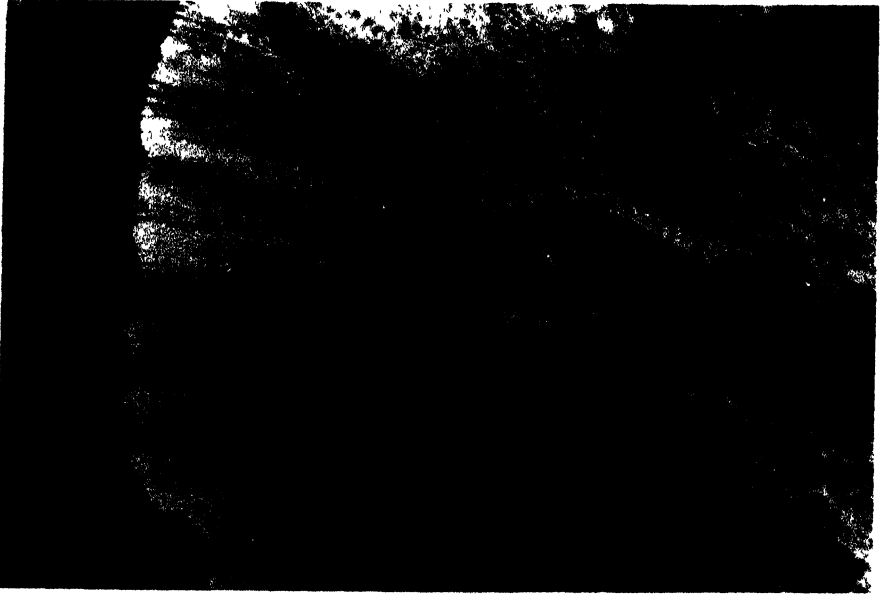


35 ×1

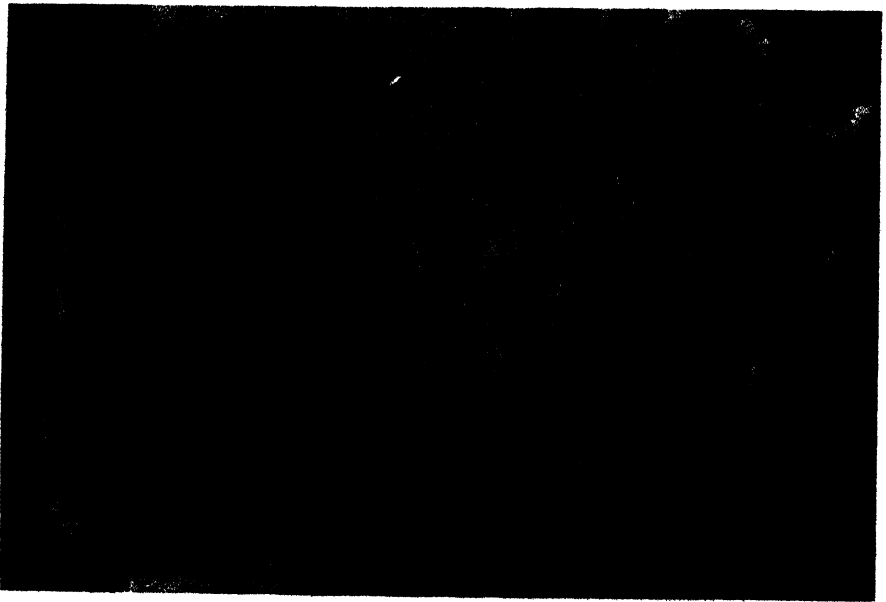


36 ×2

(35) *Favia ingolfi* sp.n. (36) *F. versipora* section.

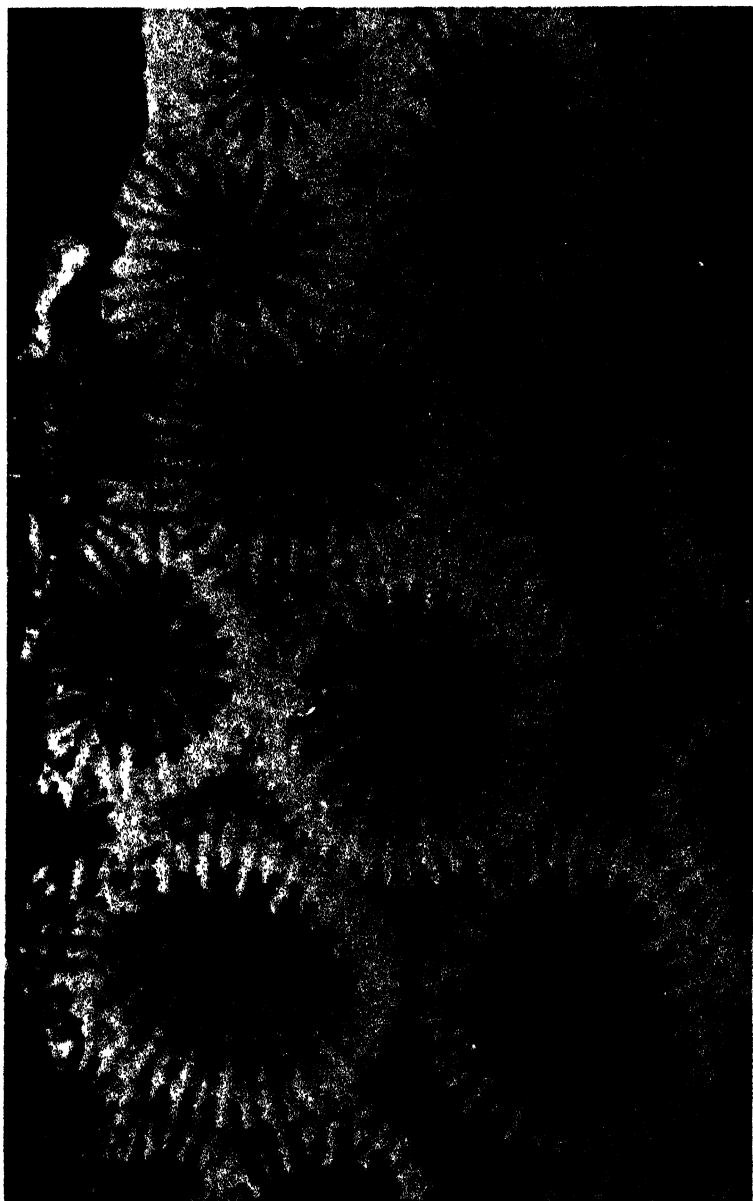


33 x2



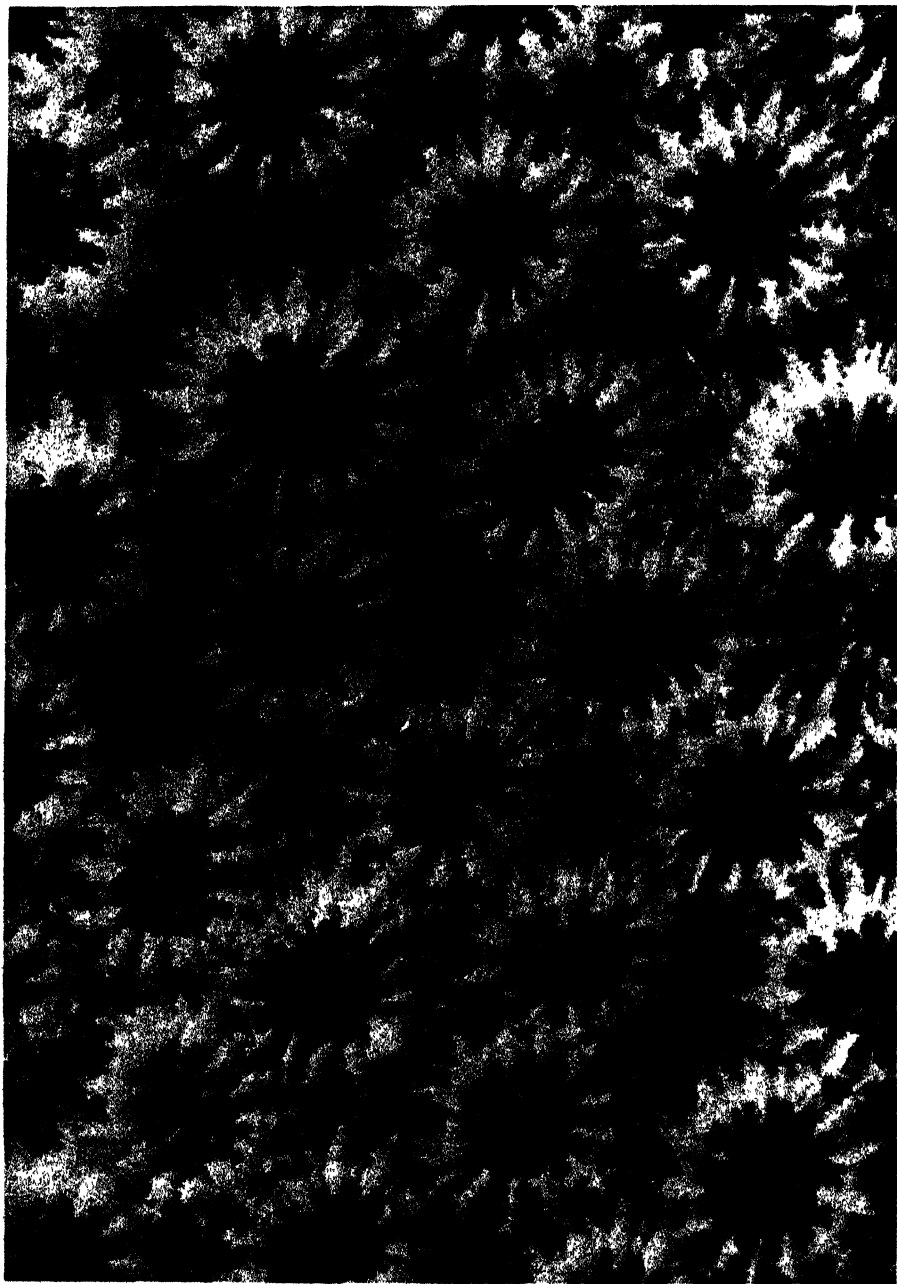
34 x2

(33-34) *Favia versipora*. surface and section.



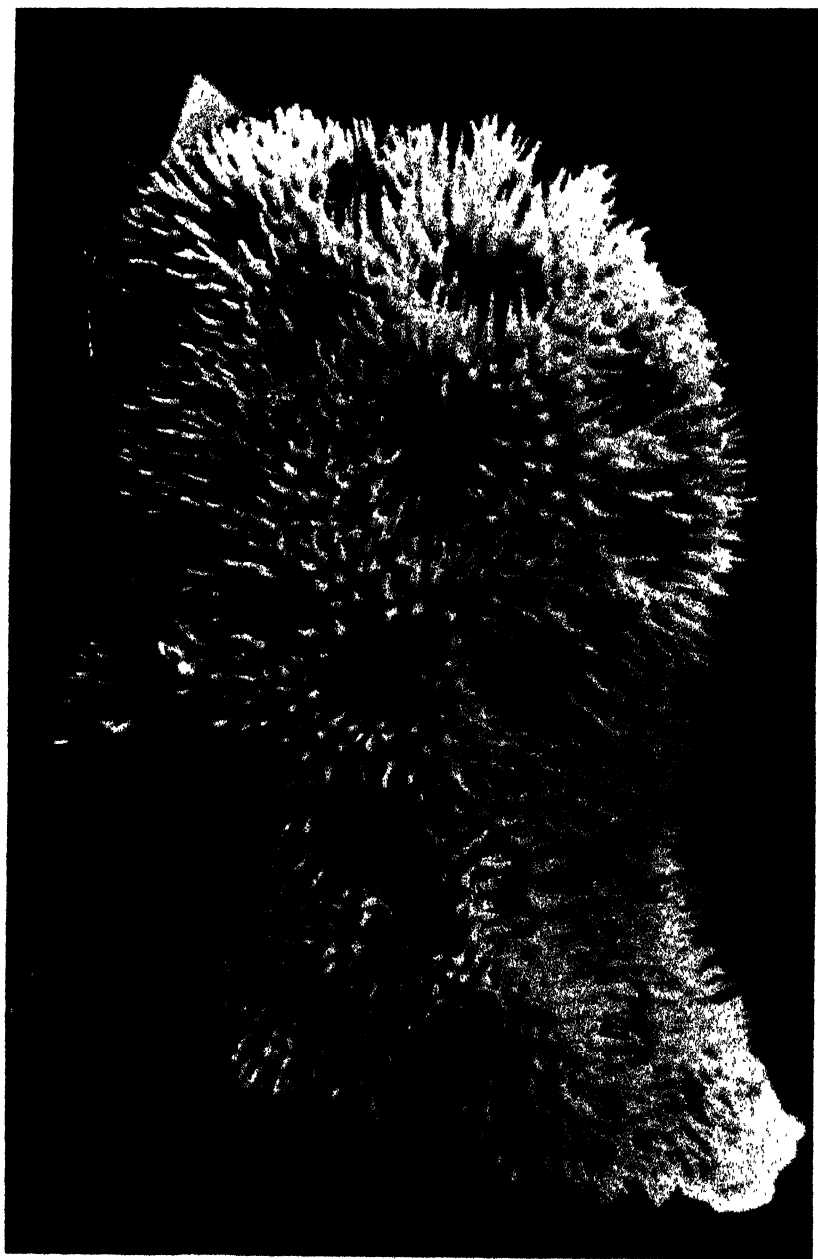
32 x6

(32) *Favia versipora*.



37 x6

(37) *Favia ingolfi* sp.n.



38 × 2

(38) *Favia hemprichi*.

17. The Reduced Building-power and other Variation in the Astrean Corals of Tahiti, with a Note on *Herpetolitha limax* and *Fungia* spp.
By CYRIL CROSSLAND, M.A., D.Sc., F.Z.S.

[Received July 16, 1930: Read February 3, 1931.]

(Plates I.-XXII.*; Text-figures 1-13.)

INTRODUCTION. (Pls. I.-III. and Pl. IX. fig. 18.)

The collection upon which the present paper is based was made independently of that used for my paper published in these 'Proceedings' in September 1928†. Nearly all the material is from the lagoon of Pa'ea, collected during the seventeen months of August 1928 to December 1929, this second visit to Tahiti having for its object an intensive study of a defined area as well as its coral fauna.

This lagoon, with that of Punaauia to the north, make up about two-thirds of the west coast. Both differ from all others round Tahiti in being "fringing," i. e., with no deep lagoons, the water over most of the reef being only one or two fathoms deep. For the last kilometre to the south a narrow channel, with depths of 10 to 24 metres, leads into the broad lagoon of Maraa, on the south coast, and northwards are two deep pools, about 14 metres, which may be relics of a once continuous lagoon which has been filled in by coral growth, lagoon-formed coral débris, and, in places, alluvium from the island. Around these pools and channel, on the sides which the current strikes, i. e., the eastern and southern sides, coral growth is vigorous, forming large flats such as are not found in the northern part of Pa'ea or any part of the Punaauia Lagoon. These beds, except in the southern channel, too ill-defined to be styled reefs, are composed of the usual inshore species, the main mass made of *Porites* (*Synaræa*) *convexa* with blue, violet, and brown *Montipora* (in leafy sheets, largely), with local additions of leafy species of *Pavona* (*P. frondifera*, *P. prætorii*, *P. decussata*, and *P. cactus* are all present, and possibly others) and the "stags' horn coral," *Acropora formosa*. Smooth species of *Porites* are also present, but never in the quantity of the knobby *P. convexa*, whereas, on the submerged flat, this species is practically entirely replaced by the ordinary smoothly massive forms.

A curious feature of Tahitian lagoons, which reaches its maximum in that of Pa'ea, is the prevalence of leafy forms. Leafy *Pavona* spp. occur everywhere on shore reefs; the abundant species of *Montipora* all have spreading bases and large bracket-like expansions, from the centre of which the branches arise, or the whole of a large colony may consist of a series of big brackets one over the other. In Pa'ea we not only have a great abundance of these forms, but *Porites* (*Synaræa*) *convexa* often forms large paper-thin unattached sheets in the same way. Most strangely of all, the solid species of *Porites* often have thin horizontal expansions near their bases. Yet the genera with which such thin brackets are usually associated, such as *Echinopora*, *Merulina*, and

* For explanation of the Plates, see p. 390.

† The explanation of the plates in this paper is not clear. I append a correct copy at the end of the present paper.

Turbinaria, are totally absent, while *Pachyseris* has been found twice and *Echinophyllia* only once in nearly three years' collecting.

Very little fresh water enters these lagoons; the main streams flow out directly through the Pa'ea and Punaauia gaps, while the lagoon water, fed by the surf, constantly flows over shallow bars into the gaps whatever the state of the tide. Conditions are, therefore, at the optimum for coral growth; yet, though prolonged and careful search has produced some astreae larger than those previously recorded (a specimen of *Favia stelligera* measuring 120 cm. \times 100 cm. \times 40 cm. deep, one of *Lobophyllia* of normal size, 4 feet high and 6 feet in diameter), the conclusions drawn from my previous collection and observations, whether on the coral fauna or the regression of the reefs, have been supported and extended. A few more species have been added to the list: *Favia hemprichii* is recorded from the Pacific for the first time; *F. ingolfi* is a new species; a large paper-thin Fungiid* is probably a new species of *Echinophyllia*; of *Pavona* there are one or two new species, or possibly new varieties; *P. maldivensis*, of which one specimen was found in 1925, has provided a series clearly connecting the species with the apparently very different *P. explanulata* and with *P. duerdeni*. Of the list of genera given as absent from Tahiti in my former paper, one has turned up, a single large specimen of *Astreopora*† having been found at the end of thirty months' search.

I should add a note on the immense ecological value of the solid species of *Porites* to the fauna of most of the lagoons. These form big cylinders, in every stage of growth and decay, scattered on the submerged flat, where they entirely replace the semi-solid *P. conveza* of the shore reefs. Without the support of these most of the species of this, the richest part of the lagoon, would be unable to grow, and the fauna would be greatly impoverished. Few species can establish themselves on the sand-rasped bottom; besides *Porites*, only *Acropora cytherea* (called *A. hyacinthus* in my previous paper—but I now think the species are distinct), *Leptastrea purpurea*, a *Montipora*, *Agaricia ponderosa*, and the hydrocoralline *Millepora* are capable of so fixing themselves. Even *Lobophyllia* is always supported by *Porites*. Of these species, *Acropora cytherea* is the only one with much building importance; its great corymbose colonies, often two metres or more in diameter, are in places very abundant just within the barrier edge. Here, however, the ocean water, poured over by the surf, is free from sand; further within the lagoon this species needs support as much as do the other corals, and is never found on the bottom. *Agaricia ponderosa* forms big solid masses, but, like *Acropora cytherea*, is common only in places on the outer submerged flat, usually near a pass. In most lagoons it is rare.

The peculiar influence of the polychæte worm *Phyllochætopterus* sp. upon corals has not hitherto been recorded. It is not common as a coral commensal, but, when found, is in numbers together. Colonies of smooth-surfaced *Porites* and of *Millepora* are occasionally found in which the surface is raised into little cones, about 5 mm. across the base and 3 mm. high, from the tops of which the worm-tube projects a millimetre or so. I have found the same worm in one specimen of each of three other corals, *Cyphastrea microphthalma*, *Leptastrea purpurea*, and *Lobophyllia corymbosa*. In the former two the effect is very striking, the cones being prolonged into branches, giving the colony a strange

* My collection of the colonial Fungiidae will be used by Professor Matthai in his promised revision of the group.

† I cannot give a specific name as the development of septa and columella, upon which the species are mainly distinguished, shows every possible variation in different areas of this large specimen.

appearance for any species of these genera, while the calyces become thin-walled, with delicate exsert septa. In the latter the tubes apparently lay in the body-cavities of the polyps, and have been calcified by them, but seem to have been no detriment to their growth. The former two examples are shown on Pl. I., the *Lobophyllia* on Pl. IX. *Montipora effusa* Bernard has been stated by him to owe its strange branches to worm-tubes, but neither in this species, which is common in Papeete Harbour and the neighbouring lagoons, nor that so abundant in Pa'ea lagoon, which has tapering gently-curved branches, have I found any worms.

This latter species is interesting in that it is the only one which shows any conspicuous relation to current; the lagoon current here is always south, and the branches of this *Montipora* are longest on the north sides of the colonies; those on the southern sides are occasionally seen to bend laterally and northwards. Besides this I have occasionally seen *Porites* form ridges, and even plates, which are set against the current; but otherwise there are no effects upon the forms of colonies due to their being exposed to currents from one direction.

As a preliminary to experiment I began attempting to define the species and the range of their variation, and, having the advantage of Matthai's two monographs on the Astreans and Vaughan's large works, it seemed that the identification of the few Tahitian species would be an easy matter. I found, however, that I was frequently unable to divide my species on either Matthai's scheme or on Vaughan's (where these differ), and seemed faced with disagreement with both these authorities, whose work is based on the examination of hundreds of specimens, where I, by diligent search, have obtained tens. The explanation is found in the special characteristics of the Tahitian fauna.

In my paper of Sept. 1928 I showed that the Tahitian coral fauna is restricted, largely by the absence of many members of the Astrean division and the small size of those which do exist here, and that this restriction is due to some ecological cause, and not to the geographical isolation of Tahiti alone. I now find that the minute structure of the coralla is modified in a way which shows that the surviving species have had to adapt themselves to conditions unfavourable to normal building. Whether this adaptation is purely ecological or is hereditary remains to be seen; in one of the forms of *Leptastrea* it is the latter; but the occurrence of similar changes in corals so widely separated as the Astreans are from *Herpetolitha* and *Fungia* suggests the former. It gives a suggestion as to why the perforata (e. g., *Acropora* and *Porites*) are here in strength, unaffected by conditions which make it difficult for the imperforata to survive.

It seems, too, that variability is specially great in Tahiti—compare the monospecific genus *Millepora*. In the Red Sea I found only three forms: (1) thin parallel netted plates, of a yellow-brown colour, and (2) solid irregular plates, resembling the *M. platyphyllia* from Cocos Keeling Atoll figured by Vaughan (1918, pl. 93), but never attaining the size given by Wood-Jones, and always of a light greenish-grey colour; (3) honeycomb facies, with no intermediates. Here in Tahiti the genus is far more variable, comprising the four distinct forms I have already described, and a fifth, massive form, while intermediates between all five are easily found.

The subject of the constitution of local coral faunas is one worth extended investigation. Why, for instance, does *Pavona varians* become an appreciable reef-builder in the Maldives, where there are no leafy species (Gardiner, 'Fauna and Geography of the Maldives, etc.'), while here, though the former is in abundance and in great variety, it forms nothing but small crusts, while the leafy species occur in quantities? Why is *Porites conveza*, the commonest of corals

here, growing to masses up to 12 feet in diameter, not recorded elsewhere? These two species especially seem to form an almost inextricable tangle of varieties, and, in short, it would seem as though this far oceanic island had been an evolutionary centre for corals to some extent, as it has been so conspicuously for plants.

A sentence from a lecture by Bateson—"A species is a real thing, but we do not know what it is"—seems peculiarly appropriate to corals, and it appears to me that the corals are particularly appropriate material for this discovery, and the study of them may well lead to advance in our knowledge of the methods of evolution. My experience indicates emphatically that coral species can best be studied in a (temporary) laboratory by the reef, and not in museums, and should, of course, be accompanied by experimental work. For one thing, no museum has more than a few specimens of normal size, and the small pieces, which alone can be transported and stored, are often misleading. I return to this subject when dealing with *Lobophyllia*.

Matthai (1914, p. 35) has shown that in adult *Astreans* the thecal walls and columella are not independent structures, but are formed by the fusion of the ends of the septa. This is true of the columella in development also*. The septa being the morphological foundations of the whole skeleton, the effects of any reduction of building-power are most prominent in them. The following are the variations from the normal found in Tahitian *Astreans*, the details of which, and the difficulties they make in specific determination, being given in the description of the species:—

(1) The septa are cut into narrow teeth.

It is to be observed that long septal teeth are the result of reduced growth and are not additional as might be supposed. This form of reduction is found regularly in the local variety of *Favia versipora*, in *Cyphastrea microphthalmia*, a very few calyces of *Leptastrea*, and frequently in *Lobophyllia*; also in *Fungia* spp. and *Herpetolitha limax*.

As this is a point of fundamental importance, observations in support must be given. It is shown (1) by the general comparison of Tahitian specimens among themselves and with descriptions of those from other seas; (2) by direct comparison of adjacent septa, where one is toothed and the other is not, the ends of the teeth corresponding to the edge of the entire septum; (3) by the fact that it is the narrower septa that bear these long teeth—the broader are entire or have broad, blunt teeth. This is most easily seen in the large septa of *Fungia* and *Herpetolitha*.

HERPETOLITHA LIMAX (Esper).

The species recorded from Tahiti is *H. stricta* Dana, who named his specimen from Fiji, *H. crassa*. Both species are described by Vaughan, the latter from Keeling Atoll, and by Gardiner, from Funafuti. Vaughan also places the twelve specimens collected by the U.S.F.S. 'Albatross' in Papeete Harbour, Tahiti, under *H. stricta*, and agrees with Gardiner that records of *H. limax* from Tahiti need verification.

After detailed tabulation of sixty specimens between 152 mm. and 480 mm. in length (the latter, apparently, a record for the genus), I concluded that all three species are here present, but that the series cannot be divided at any point.

* See, for instance, Boschma, "Post-larval Development of the Coral *Meandrina areolata*," Carnegie Inst. Wash. Publ. 391, 1929. For the adult form of this coral, see Matthai, 1928, p. 29, under the name *Manicina areolata*. Compare the outlines of young buds of *Leptastrea* in text-figs. 1 & 3, pp. 360 & 364.

Of these 60 specimens, 20 have no more bending of the septa than has *H. limax* as described by Gardiner; in 19 it is as marked as in Vaughan's figures of *H. stricta* and *H. crassa*; while in the remaining 21 the calyces are usually of the *limax* type, with a few of the semi-radial pattern, and in one specimen half the corallum is *limax* and half is *crassa*. Since this work was finished I find the conclusion has the support of Dr. Boschma, but I do not agree that the radial arrangement of the septa is due to increased age *alone* *.

In Tahitian specimens of this species, as in some specimens of *Fungia* spp., the septal teeth are quite unlike any published description, being long, parallel-sided, or complicated, as shown in fig. 4 of Pl. II. When the septa bearing such teeth are adjacent to those of normal form, and so can be directly compared, it is evident that these long teeth are due to the loss of the intervening portions of the septal wall. Exactly similar is the case of the costal spines of the undersides of certain specimens of *Herpetolitha* and the whole central areas of a few others. The normal condition is for the costæ to be distinct, as low ridges, for 2 or 3 cm. inward from the edge of the disc, bearing short, broad, granulated spines, as figured by Vaughan, 1918, on pl. 51, fig. 3 b. In a few specimens the spines of the central area are so different that it seemed that another, and new, species occurred here. In these specimens, or parts of the specimens, the spines are long, slender, and crowded, giving a furry appearance to the areas they cover (Pl. II.). The explanation is found in sections of the coralla, which show that in normal specimens the basal plate is mainly formed by the fusion of the costæ and their spines. Where fusion is not complete, as at the sides of the perforations, the spines are seen to be quite different from their appearance on the costal ridges, or in surface view anywhere on the lower surface, being long and slender and swollen towards the base, like ninepins. A section through a long-spined specimen shows that the spines are exactly the same, but incompletely fused or quite free, and it is to this—not to any greater development of spines—that the strikingly different surface-view is due—to loss, and not to growth (Pl. II. fig. 3; Pl. III. figs. 5 & 6).

Herpetolitha limax shows another disorganization of the deposition of CaCO_3 , this time in the direction of excess. The pathological thickening of some of the septa in certain of the Tahitian specimens collected by the U.S.F.S. 'Albatross' in 1899 is referred to by Vaughan (1918, p. 130). In many of my specimens this has gone further, irregular granular masses projecting above the septa in places. The flesh above these dies in the centre of the affected area, which is then occupied by confervoid algæ. The morbid growth may spread at its edges, while the centre is hollowed out, until considerable areas are killed and form shallow depressions. These are not, as I supposed, due to the collection of sand on the disc; the disease is from within—not an accident from without. In *Favia stelligera*, and other Astreans, analogous disorganizations occur, as described below.

FUNGIA spp.

The specimen chosen for illustration of dissected septa on Pl. II. was identified by me doubtfully as *F. fieldi*. Dr. Boschma, having kindly examined photographs of the whole specimen, tells me that *F. repanda* and *F. fieldi* are hardly distinguishable. *F. concinna*, and its synonym *F. plana*, are also probably only forms of *F. repanda*. See his notes on these species, and on *F. paumotuensis* and *F. scutaria*, in his paper on the Fungidæ collected

* The Fungidæ collected by Mr. Cyril Crossland at Tahiti, etc. P. Z. S. 1929, p. 46. Horst Madreporaria of the 'Siboga' Expedition, 1921.

by Mr. Cyril Crossland at Tahiti, etc. in these 'Proceedings,' 1929, pp. 44 & 45. My own experience with the latter two species is that odd specimens can usually be placed in one species or the other, but, if a series of fifty to a hundred specimens be taken, division becomes impossible, even if all the specimens are of good size.

There is a curious point about *F. fungites* and *F. cooperi*, of which one specimen each is recorded from Nuka Hiva, in the northern Marquesas. The 'St. George' was six weeks in the group, which I spent listing the coral species of this very restricted fauna. No Fungidae were ever seen in the southern islands, and *only once* in the northern, when four specimens were seen lying together within an area of a square yard or so. Under these circumstances it seemed obvious that all were from the same stock, but the two specimens I took now appear as two unrelated species.

It appears to me that the species of *Fungia* and its allies need drastic revision. This can be done properly only by the reef side, and must be accompanied by breeding and other experimental work, which would probably throw valuable light on the species problem in general. The corals in so many cases show divergence into quite distinct forms without any actual separation of species.

(2) The septa are abnormally thin in practically all Tahitian *Astreans*, so that, where thickening of the septa forms a specific distinction, as in *Leptastrea* and *Lobophyllia*, discrimination becomes nearly impossible.

(3) The septa are conspicuously narrow, and fail to reach the columella in forms II., IV., and VI. of *Leptastrea*, in *Cyphastrea microphthalma*, and certain parts of the coralla of *Favia stelligera*. There is also a reduction of number and failure to reach the thecal wall in *Leptastrea* IV. and VI., and those parts of *Favia stelligera* with hypertrophied columella.

(4) Palial lobes are absent in species characterized by their conspicuous development. This is practically complete in the local variety of *Favia versipora*, the new *F. ingolfi*, and is frequent in *F. stelligera*.

(5) Degeneration, or even absence, of the columella, which is loosely made in almost all specimens of *Favia versipora* and *F. ingolfi*. It may be degenerate or hollow in *Lobophyllia corymbosa* and *Favia hemprichi*, absent altogether in parts of colonies of *F. stelligera*, and hypertrophied in others. In *Cyphastrea microphthalma* it is absent, as also in parts of colonies of *F. hemprichi*. In *Leptastrea* all stages of degeneration are found.

(6) Besides these septal structures, the peritheca is also affected, becoming vesicular in species in which it is normally dense, as in specimens of *Cyphastrea microphthalma* and *Favia versipora*.

(7) The walls between calyces, i. e., the two thecae and the peritheca between, are thin, as in *Leptastrea*, in *Favia stelligera*, and in all three forms (hitherto species) of *Lobophyllia*.

(8) The effect of the surf floods upon *Favia stelligera* and *Lobophyllia* is to cause increased delicacy of the theca and septa, while solidifying the stock. Complete shelter in the lagoon and in crevices causes increased size and openness of the calyces, thinner septa, and looser columella in *Favia versipora*. Some influence of physical conditions on the forms of *Lobophyllia* is described in the systematic part.

SYSTEMATIC.

The Astreans of my first collection were named for me by Professor Matthai as in the column on the left. On the right are my 1928-9 specimens, with emendations of nomenclature due to Vaughan, who had access to Dana's types. In other cases species considered distinct by Matthai and other authors are run together. Reasons have been given for thinking that some of these fusions may be local phenomena, and further reasons for the same possibility are given below.

Collection, of 1925-6.

- (1) *Cyphastrea microphthalma*.
One very small specimen.
- (2) *Leptastrea roissyana*. }
- (3) *L. ehrenbergana*. }
- (4) *Lobophyllia corymbosa*.
Four specimens.
- (5) *Favia versipora*. }
- (6) *F. wakayana*. }
- (7) *F. solidior*. }
- (8) *F. complanata*. One specimen
only.
- (9) *F. acropora*.
- (10) *Favia*, sp. n. One specimen.

Collection of 1928-9.

- (1) Numerous similar specimens, from special habitats.
- (2) and (3) These two species grade together, and with *L. solida* and *L. immersa*.
- (4) *L. corymbosa*, *L. costata*, and *L. hemprichii*. 25 specimens in all, in which intermediates between all three species are found.
- (5), (6), and (7) all grade together in one degenerate Tahitian variety of *F. versipora* Lmk.
- (8) Not found.
- (9) *F. stelligera*. Nine specimens.
- (10) Not found.
- (11) *Favia ingolfi*, sp. n. One specimen.
- (12) *F. hemprichii*. Nine specimens.

Genus CYPHASTREA.

CYPHASTREA MICROPHTHALMA. (Pl. IV. figs. 7 & 8.)

When Matthai made his complete revision of this genus, in 1914, this species, which is common in the Red Sea and Indian Ocean, had been recorded from no part of the Pacific. In 1925 Hoffmeister recorded one tiny specimen from Mayor's Samoan collection, dredged from 18 fms., similar to the single specimen I found on a shore-reef of Tahiti in that year. In 1928-30 I found it quite common in certain localities, under special conditions which are probably temporary, but only as small crusts, generally one, but sometimes three inches in diameter. The favoured habitats are: (1) A shore reef of Papeari, which, in October 1929, was restarting growth after the destruction of its corals by the flood of January 1926. (2) In Pa'ea lagoon, on sandy shallows off the mouths of two adjacent streams which have been dry for more than a year, the rainfall of the last two years having been exceptionally low. (3) On a broad flat of corals adjoining the shore north of the above area, the corals having been largely killed off by the growth of a dark grey sponge. It would seem that ecologic conditions are against this species almost to the point of its total suppression in the Pacific; but that, a field being cleared for it, it can immediately respond, as do nettles and docks on cleared land. It generally grows in the open, but may be in shaded cavities in the latter habitat, and in this, as in locality, follows the distribution of *Leptastrea*.

The species is characterized by "Calices (having) the interior obscured by

the considerable thickness of the septa . . . ; of these, ten meeting the columella (are) equally thick . . . ; columella thicker than in the last two species, with higher rods projecting into the calyx." I quote Matthai, omitting the particulars in which my specimens agree with the normal ones he examined, and upon which I have satisfied myself of the specific identity. Matthai's nine photographs, like Vaughan's and Faustino's, emphasize the difference shown by the Tahitian series, in which, in all the 46 specimens I have examined, the calyces are open, since the septa, though thick and spiny above, are thin and narrow below, descending vortically (Pl. IV. fig. 7). As the calyx is often twice as deep as it is broad, the structure of the lower parts can only be shown by section. It is then seen that none of the septa meet the columella, and that, in most cases, there is no columella for them to meet, the bottom of the cup being closed by a smooth, thin, horizontal dissepiment. In one case this is near the surface. In other cases this dissepiment may bear an irregular spine or two, or a small amount of granular matter either spread out over the bottom of the calyx or heaped into a rudimentary columella. The lower parts of the septa are dissected into narrow, often excessively delicate teeth, recalling those of the Tahitian variety of *Favia versipora*, but, so far from forming the columella, they do not, as a rule, reach the centre of the calyx (Pl. IV. fig. 8).

The peritheca is usually as dense as in Matthai's specimens, in marked contrast to the thin dissepiments of the calyces. In one or two specimens it is more vesicular, but the vesicles have thick walls. Few specimens are, however, thick enough to give satisfactory sections of the peritheca.

Genus LEPTASTREA.

(Pls. V.-VIII. and text-figs. 1-6.)

All the five species given by Matthai and Vaughan occur in Tahiti, though *L. bottæ* (*solida*) and *L. immersa*, the species with exsert calyces, are rare and hardly typical. Intermediates between all five abound, and since (perhaps as a peculiarity of this fauna) neither author's definitions can be strictly applied to more than a small proportion of the colonies, the rules of nomenclature demand that all be grouped under one specific name, which will be *L. purpurea* Dana, 1846. This is a misleading arrangement, quite unsuitable to the stage which the recent corals have reached in their evolution; no one type should take precedence of any other, nor has this custom, in the case of monospecific genera, any advantage from the viewpoint of the pure systematist.

Matthai forestalls criticism by frankness regarding the difficulties of his system, while Vaughan remarks that "those who have had wide experience with stony corals well know . . . that dogmatism on the relations of species is hazardous."

ECOLOGY.

Lepastrea is by far the commonest Astrean in Tahiti; it is the coral which lives nearest to the shore, often close under the beach, in little colonies forming crusts on dead coral or basalt stones, with the algæ *Dictyota*, *Turbinaria*, and *Padina*. A few yards out it is accompanied by small colonies of *Psammocora contigua*, *Porites* (*Synaræa*) *convexa*, smooth *Porites*, and *Pocillopora damicornis*, with leafy species of *Pavona* abundant in places. The colour of these inshore colonies is variable; it may be dark brown, almost black, in the calyces, from which the peritheca stands out as a whitish network, or it may be a light yellow-brown almost uniformly. I find no skeletal differences corresponding to these colour variations. On the submerged flat

area small colonies such as these of the shore-belt are rarely seen, *Lepastrea* here attaining diameters of 1 to 3 feet either as a crust on the bottom or as upstanding masses, such as are illustrated in the text on pp. 366 & 367. These, however, are found to be lumps of dead *Porites*, with but a thin coating of the *Leptastrea*, only a few centimetres or millimetres in thickness. As noted in the Introduction, this is one of the three corals capable of growing directly on the bottom of the sand-swept submerged flat, and the only one which cannot escape the scour by upward growth independent of chance support. Besides their great size, these bottom-living specimens are distinguished by their nearly uniformly small, generally almost round calyces. Distorted and larger calyces perhaps occur more frequently in my collection than in nature, as the bottom-living colonies are difficult to obtain. In colour they are a light yellow-brown, but, as usual in most corals, this turns to chocolate on the shaded parts. The polyps are often a dark dull green. On the lagoonward slope of the barrier edge the genus is not common, occurring as small colonies, a few inches across, in crannies. The majority of these specimens are distinguished from those of the other two habitats by their large irregular calyces, some of which are compressed into long, narrow, almost meandrine forms.

While there is a complete overlap in the characters used for specific definition, by neglecting detail and looking at the specimens in a broad way the majority can be placed in groups corresponding to *L. roissiana* and *L. ehrenbergiana*. Further, while no two specimens of the *roissiana* facies from the submerged flat are quite alike, and there is complete overlap in their characters, there is individuality, certain peculiarities extending to the whole area of large colonies, independently of exposure to light or to current, which is always to the south in this part of Pa'ea lagoon. The differences are therefore innate, the beginnings of species differentiation, which in course of time, or through changing conditions, might be carried to completion. It is possible that this has already gone further in localities where coral growth is more normal than we find it here. There is also indication of selection by environment in the proportions in which the varieties, described later, occur in the three habitats, thus :—

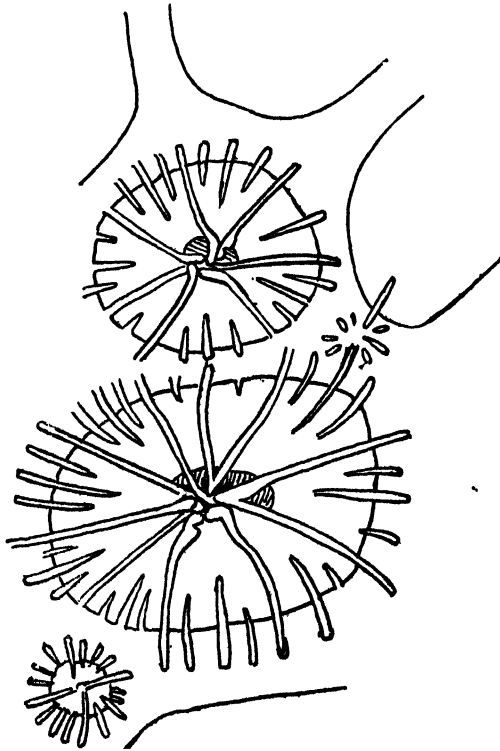
| | | | |
|-----------------|-------------------------|----------------|--|
| Inshore. | Facies II. | 29 specimens. | |
| | III. | A few calyces. | |
| | IV. | 15 specimens. | |
| | VI. | 6 " | |
| | <i>L. solida</i> | 2 " | |
| | — Total examined | 52 | |
| Submerged flat. | Facies II. & III... | 6 specimens. | |
| | IV.... | 8 " | |
| | V.... | 2 " | |
| | — Total examined | 16 | |
| Barrier edge. | Facies II..... | 4 specimens. | |
| | III..... | 25 " | |
| | IV..... | 11 " | |
| | V. and VI..... | None. | |
| | — Total examined | 40 | |
| | | — | |
| | | 108 | |
| | | — | |

Owing to overlapping of characters these numbers are only approximate, and another worker would probably give them differently, though the result

would be the same. This proviso applies to most of the numerical arrangements which follow.

The differences between the extreme forms of this monospecific genus are enormous. Compare, for instance, Dana's type of *L. purpurea*, shown by Vaughan (1918, pl. 30, figs. 1 & 1 a), with *L. transversa* (pl. 31, figs. 1 & 1 a), and both with Matthai's *L. ehrenbergana* (1914, pl. 18, figs. 2 & 7) or Vaughan's figures of the species with exsert calyces, both of the 1914 and 1907 publications; also my figures on Pls. V. to VIII. and the drawings on pp. 360, 363, and 364. These differences are mainly due to a progressive reduction in number

Text-figure 1.



Leptasterias, specimen No. 5, of the submerged flat series. Two calyces and two buds. $\times 15$.

These show that the columella is made by meeting and swelling of the edges of the septa.

Some of the septa do not pass on to the wall, and are shown with distal ends imperfect.

and size of the septa, and, since the columella is formed from the septa, of the latter also. As anatomy follows upon physiology, it is important to know what is the value of columella and pallial lobes to the polyp, and how it is possible that such almost universal structures should vary so greatly, and even be totally absent, without bringing life to an end. What is the function of the parts of the polyp below the columella which are periodically cut off

* The specific name *transversa* may be misleading; the compressed columella is always longitudinal when the calyx is not round, and there is no real difference between it and an elongated columella in the *ehrenbergana* types.

by the dissepiments? (Matthai, 1918, p. 9). Do they collect excretory material which is thus got rid of? Why do these parts extend so deeply in *Leptastrea*, and why are dissepiments rarely seen? What is it that inhibits upward growth, so that only thin crusts are formed? In Mayor's experiments on the rates of growth (1914, p. 64 and pl. 12) the small specimen of this genus added nothing to its weight in fifteen months, and it is obvious that the small inshore colonies of Tahiti remain of nearly constant size, since the average has been the same since 1925.

The formation of the columella cannot be made out when it is compact and fully developed; but, where it has not been solidified by calcareous deposition, it is seen to originate by direct overlapping of the septal ends, in contrast to *Favia* and *Lobophyllia*, where it results from the clockwise twisting of septal trabeculae. A "transverse" plate, upon or against which the septa meet (both conditions are found), may be formed by the fusion of two opposite septa, or may be absent. The series of drawings in text-figs. 1, 2, & 3 show stages in the simplification of the columella leading to its disappearance as a distinct structure; the young buds in text-figs. 1 & 3 especially show its origin. Only one stage is shown by Vaughan (pl. 31, text-fig. 1 a), none by Matthai—from which it may be concluded that this degeneration is commoner in Tahiti than elsewhere.

SYSTEMATIC.

The museum specimens of the genus have been thoroughly described by Matthai and Vaughan, who divided the genus into two groups:—

I. Calyces polygonal, not exsert.

Matthai's *L. roissiana* and *L. ehrenbergiana*.

Vaughan's *L. purpurea* (*L. roissiana*) and *L. transversa*.

II. Calyces round and exsert (except typical *L. bottæ*).

Matthai's *L. solida* and *L. immersa*.

Vaughan's *L. bottæ* and *L. immersa*.

The disagreement between the two authorities as regards Group II. is merely one of nomenclature, since Vaughan considers that the name *bottæ* has a month's priority over *solida*, both names given by Milne-Edwards and Haime in the same publication; but it seems possible that Vaughan has misunderstood Matthai's statement, which is not very clear. In the case of Group I. the disagreement is more serious. Vaughan, having access to Dana's types, found that *ehrenbergiana* is synonymous with *purpurea*, and that the specimen sent to him labelled *L. roissiana* by Matthai was a *transversa*, which he regarded as a distinct species. He also pointed out that the description of *roissiana* by Milne-Edwards and Haime applies well to *L. purpurea*. He admits that Matthai may be right in combining *L. transversa* with *L. roissiana*, but awaits definite proof of their identity. This I am able to supply. Matthai and Vaughan lay emphasis on different structures, the former dividing his species by the thickening of the septa within the calyx or upon the theca, the thickness of the walls, and general development of the columella; Vaughan laying stress on the details of the septa, whether toothed or entire, smooth or granulated, whether the columella is smooth or papillate. After much labour in attempting to find some means of classification on these lines I found that *Leptastrea* shows the reduced building power of the other Astreans in Tahiti, and therefore

these characters fail us as a means of discrimination. The walls of specimens otherwise like *ehrenbergiana* are often scarcely thicker than that given in the definition of *roissyana*, and their maximum is only 1.0 mm. instead of the 1.5 mm. given by Matthai; there is no correspondence between the granulation of the sides and edges of the septa and their toothing, the former being common, the latter rare, in all my series; the columella may be solid and papillate, broad and smooth, compressed or reduced to the overlap of a few septa, in quite an irregular way. There is complete overlapping, as shown by the descriptions given below.

For purposes of description I propose the following subdivisions of the specimens with calyces not exsert, based mainly on the state of development of the septa:—

I. As Dana's type of *L. purpurea*. Septa thick, sloping, two cycles and part of the third reaching the columella, crowded in the calyx, so that their tops make a funnel-shaped depression. Columella dense and papillate. Unfortunately the type-specimen is only a fragment, 85 mm. in longest diameter; as it is 38 mm. thick, it must have been broken from a large specimen, the other parts of which would probably have shown interesting variations; compare, e. g., Faustino's figures of *L. bottæ (solida)* on his plate 21, the lower of which is hardly distinguishable from Dana's type. This facies is not illustrated by Matthai, but is shown by Vaughan, 1918 (pl. 30, figs. 1 & 1 a). It does not occur in Tahiti, but I have an example from the Great Barrier Reef, given to me by Mr. G. W. Otter, in which the septa are even more granular, thicker, and consequently more crowded, than in the type.

II. Septa less regular, being thinner, and some narrower; hence a more open calyx, which is also deeper, so that the broader septa descend vertically. Illustrated by Vaughan (pl. 30, figs. 2 & 3 a), and by Matthai (pl. 17, figs. 5 & 7).

III. Some large calyces narrow and elongated, or otherwise deformed. Septa all vertical; two cycles, or nearly, reach the columella, but in Tahiti the crowding of the septa, noted by Matthai as characteristic of *L. ehrenbergiana*, does not occur. Columella generally dense and papillate, but may be degenerate or compressed. This form is well figured by Matthai, but not noted by Vaughan, though forms II. and III. are usually found on the same colony. Fig. 9 on Pl. V. illustrates a Tahitian example, No. 13*, from the barrier edge. Note the thin walls and septa, and compare with Matthai's fig. 5 on pl. 17 and figs. 2 & 7 on pl. 18.

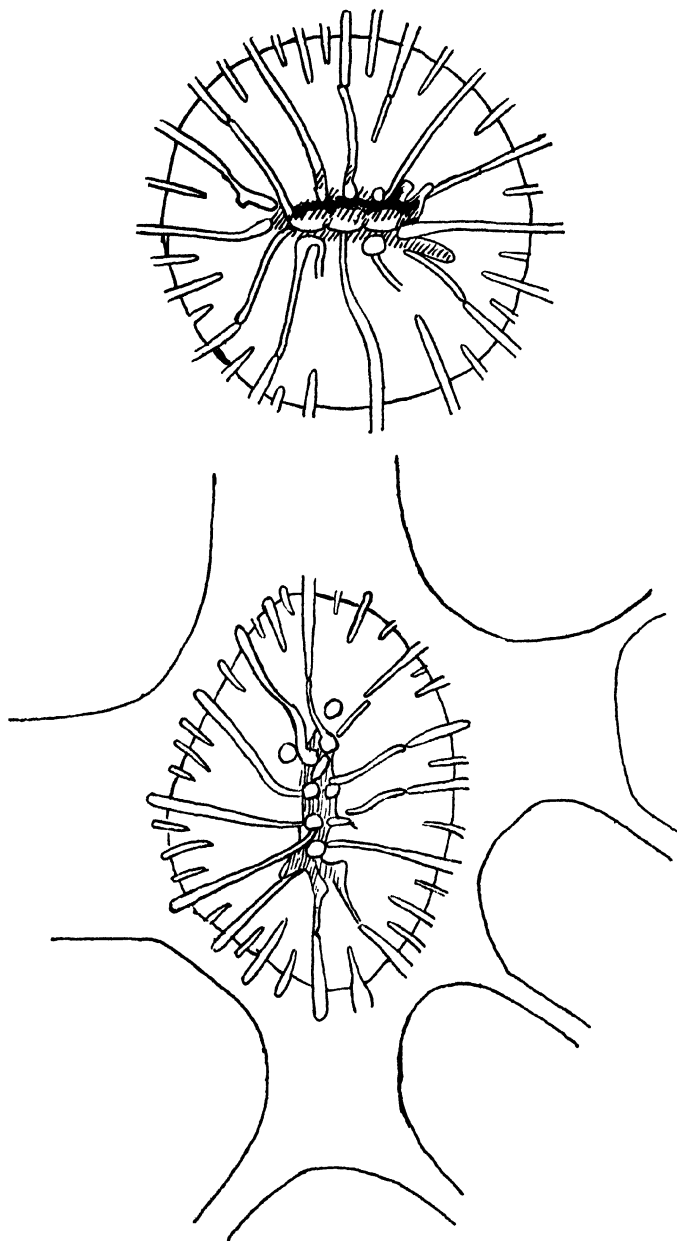
IV. Majority of the calyces small, 2 to 3 mm. in diameter, and often nearly round. Not more than ten septa reach the columella, often fewer. Columella correspondingly simplified degenerate or compressed. This is illustrated by Matthai's figures of *L. roissyana*, except fig. 2 on pl. 19, and by Vaughan (pl. 30, fig. 3; pl. 31, figs. 1 & 1 a), but these figures do not show the columellæ, for which see drawings in present text.

V. In many specimens of series IV. the tubercles on the top of the columella fall into a row, and occasionally fuse into a definite smooth plate along the top of the columella. In two large specimens of the submerged flat series, this formation is found in practically every calyx. (See Pl. V. fig. 10, and text-fig. 2.)

VI. Calyces small and regularly polygonal, walls thin and calyces open,

* The serial numbers of my collection are quoted. Most of the specimens are now in the British Museum of Natural History, though some remain in the museum of Papeete.

Text-figure 2.



Two calyces from *Leptastrea*, specimen No. 9, of the submerged flat series,
with compressed columellae. $\times 15$.

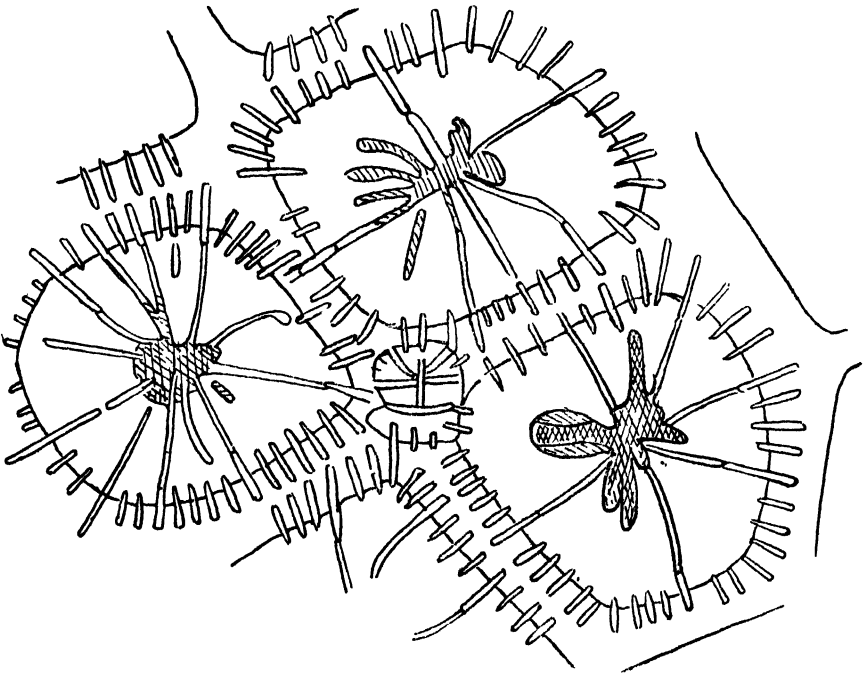
In one of them the tubercular septal ends fall more or less into a row; in the other this is definite, and forms a tripartite "top-plate," leading to the undivided plates shown on Pl. V. fig. 10,

giving the skeleton a honeycomb appearance. Septa very narrow, often broken against the theca, sometimes only six or eight complete and reaching the degenerate columella. This variety has not been hitherto described, and is figured on Pl. VI. and text-fig. 3.

THE SHORE SERIES.

Of the 51 specimens examined, 29 have a general resemblance to Matthai's typical *ehrenbergana* of pl. 17, figs. 5 & 7. Distorted calyces are rare. They have numerous sloping septa, of which some are more prominent and steeper, as in form II., sometimes toothed; but the columella may be so degenerate

Text-figure 3.



Three calyces and a bud rudiment from *Leptastrea*, L. C. 2, form VI., of the inshore series
Fow and broken septa, with degenerate columella. $\times 15$.

that the number joining it cannot be given, though in specimens otherwise similar it is 12 to 15. They are thin, and thickening in theca or in calyx generally cannot be made out. The upper parts of hummocks are occupied by more or less pentagonal calyces up to 6 mm. across. The septa may be smooth and toothed, or granular and entire, or *vice versa*. The columella may be papillate or smooth, thick or compressed, or quite degenerate, in the same colony; compressed and degenerate are the more frequent. Typical "*transversa*" columellæ may accompany large calyces with sloping septa. Walls often 1.0 mm. thick, rarely 1.25 mm.

Two specimens are distinguished by their solid walls and conspicuous intercalycinal lines, between regular calyces. Short lengths of wall are 1.5 to 2.0 mm. thick; where this occurs the thecæ are slightly exsert. Septa thin,

granular, often toothed, columella degenerate, depressed below level of septal teeth, and not compressed. These two specimens seem to connect the preceding with *L. solida* (cf. Matthai, p. 71, specimen No. 12 and Pl. VII. fig. 12).

The rest of the specimens of this series have deeper, generally smaller calyces, with thinner walls. The calyces are conspicuously more open, as the septa are narrower and steeper. Otherwise septa and columellæ are, at one end of the series, much as the preceding, with which there is complete intergradation. At the other end of the series the septa of the higher orders narrow down to mere lines on the theca, only 9 or 10 reaching the columella, until form VI. is reached, in which breakage of even main septa against the theca is frequent (Pl. VI. fig. 11 and text-fig. 3).

It is to be noted that these degenerates of form VI., though small in number, appear to be as healthy and successful colonies as the others, growing under the same conditions and to the same sizes. I have several examples of forms II. and VI. on the same stone in contact with each other.

SUBMERGED FLAT SERIES.

I have large pieces of fifteen colonies from the submerged flat, of which six have large distorted calyces of the *purpurea-ehrenbergana* facies and nine have small calyces of nearly equal size. Of these six, five are from near the barrier edge; the one example from the inner edge of the submerged flat is a peculiar growth, a number of irregular columns in a mass 27 cm. wide by 30 cm. high (text-fig. 4 and Pl. VII. fig. 13). The *Leptastrea*, however, as in all other specimens, is a mere crust a few millimetres thick covering a dead substratum, generally of *Porites*. In this case, in spite of the protection of the skin of living *Leptastrea*, the support is too decayed for identification. The largest specimen secured is the cylinder sketched in text-fig. 5, which is only part of the colony, which spread laterally below; a portion of this spreading part is also preserved. This appeared to be the most massive Astrean ever seen in Tahiti, but it is the usual mere skin of *Leptastrea*, which on one side attains a thickness of 5 cm., probably the maximum for this series. This section, it may be noted, shows horizontal dissepiments of two kinds, thick and thin.

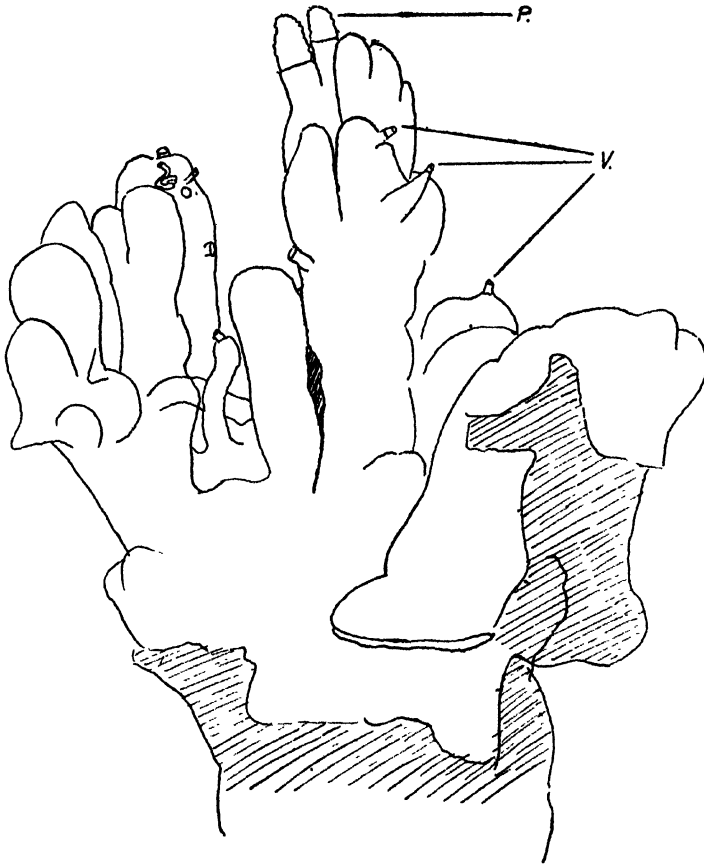
A. Facies *ehrenbergana*.

No. 2 is the specimen on a columnar *Porites* shown in text-fig. 4. In spite of the peculiar irregularity of the support, the *Leptastrea* is unique in having the majority of its calyces large, regular polygons 4 to 6 mm. across and up to 11×6 mm., though few are so distorted as this. Walls thin, usually 0.5 mm., maximum 1.0 mm. Septa remarkably strong, but not thickened specially either in the theca or on the calyx, not crowded, generally 15 meeting the columella, sloping; finely granular on exsert portions and edges, but sides are smooth; frequently toothed below, the uppermost tooth sometimes bent upwards, or the septum below this may be continuous, forming the shoulder so frequently seen in all the Tahitian series. This frequent toothing of the septa is the second feature which makes this specimen unique in this collection. Columella broad and solid, or nearly solid; depressed below the septal teeth, and consequently papillæ few and irregular. As nothing like these calyces is shown by Matthai or Vaughan, I give a photograph on Pl. VII. fig. 13.

No. 10. Rather hummocky growth, $16 \times 16 \times 14$ cm. high. Crust up to 2 cm. thick. Walls thin, 0.3 to 1.0 mm. Calyces generally large, polygonal, average 4 mm., few distorted, up to 8×5 mm. Septa steep or vertical, often thick, granular and toothed at the base, as many as 15-18 meeting the columella, which is always dense and papillate.

No. 11. A small colony, only 10×5 cm. Calyces small, but generally distorted, those 5 mm. long only 1 or 2 mm. wide. Walls 0.5 to 1.0 mm. Septa narrow, vertical, thick and granular above, thin below, rarely toothed, generally 15 meet the columella, which is dense and papillate; sometimes the papillae in a "transverse" row.

Text-figure 4.



Leptastrea, specimen No. 2, of the submerged flat series, growing over probably a columellar *Porites*. $\times \frac{1}{2}$.

P. Projecting branches of *Porites* (*Synaræa*) *latistellata* Q.

V. Openings of the tubes of the gastropod *Vermetus*.

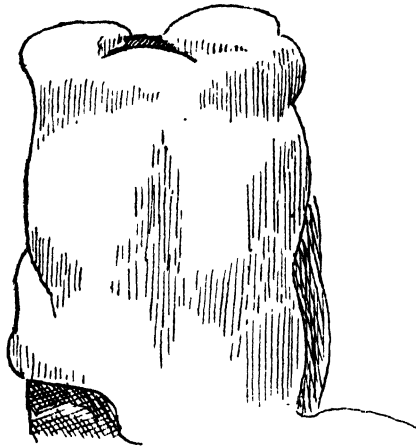
No. 12. Colony, $18 \times 13 \times 13$ cm. high. On one side calyces large, 5 mm. across, or 8×3 mm., on the other small, frequently distorted in both cases. Walls 0.25–0.5 mm. Septa thick and granular, often with a tooth or two at base, 15–18 meeting columella. Columella generally dense, but with few papillae.

No. 13. Colony, $12 \times 6.5 \times 13$ cm. high (Pl. VIII. fig. 15). Remarkable for

the distortion of all the calyces, some into pentagonal stars. There is a fusion of septa in these side branches, but only once a separate columella. Walls 1.0 to 1.25 mm., *i. e.*, thin in proportion to sizes of calyces. Calyces of every size up to 11×7 mm. or 13×4 mm.; the more regular larger calyces 4 or 5 mm. across. Septa narrow and vertical, thick in calyces, finely granular or nearly smooth, often a few teeth at base. Columella dense, papillæ prominent or almost absent.

No. 14. Growing on the vertical face and part of the top of a block of *Porites* and *Acropora*. On the former calyces are small regular polygons, 3 to 4 mm. across, and rather shallow; above, and especially near the upper edge, large deep calyces, frequently distorted, up to 9×5 mm. On the vertical face septa generally thin (but may be thick), swollen on theca, granular or nearly smooth, rarely toothed, leading to a solid papillate columella, or columella may be

Text-figure 5.



Leptastrea, specimen No. 7, of the submerged flat series. $\times \frac{1}{6}$. See also Pl. V. fig. 10.

small or compressed. Higher up complete *ehrenbergiana* facies is reached, but in many calyces septa are swollen on theca, thin in calyces, practically smooth and quite entire.

B. Facies *roissiana*

The specimens with small, regularly polygonal calyces are distinguished into smooth forms and those the surfaces of which are roughened by exsert septa and, in places, slightly exsert calyces. Where form *ehrenbergiana* grows into a hump the calyces increase in size greatly, but in these forms the calyces, under the same circumstances, remain small, but tend to become exsert; the growth upon the tubes of *Phyllochaetopterus* (Pl. I. fig. 2) has the same effect.

No. 1. Combines conspicuously thick, entire granular septa with a "transversa" columella, thin septa with a solid papillate columella, or the latter thick but smooth on top, or compressed, with a few papillæ in a single line, or reduced to vanishing point. The septa are well shouldered. Piece $\frac{1}{3}$ is almost wholly *Matthai's ehrenbergiana*, with small, regular calyces.

No. 3. Three large pieces, 24 cm., 30 cm., and 32 cm. in longer diameter. Calyces usually 4–5 mm. in diameter. Foundation much decayed, one piece quite hollow, smooth, rounded, or hummocky. Same variations of septa and columella as above, but the great majority of both are very thin. Ten or fewer septa meet the columella; in places a few septa conspicuously broader and more exsert.

No. 4. $30 \times 20 \times 17$ cm. high. Calyces usually 3 mm. in diameter. Septa nearly smooth or distinctly granular, but always entire. Six to eight meet the columella. Columella greatly compressed, sometimes broken or practically absent; frequently made of overlapping ends of septa alone. It may bear a row of papillæ or, very rarely, a top plate as in form V.

No. 5. On a sloping plate of *Porites*, 17 cm. broad, 23 cm. high, and about 6 cm. thick. Calyces conspicuously small, deep, and open, the larger 2 to 2.5 mm., many 1 to 1.5 mm. Septa fairly thick and granular, always entire, usually 10–12 meet the columella. Columella thick, dense, nearly smooth on top, or with low papillæ; or it may be hidden by meeting of septa in the centre. It is not often compressed (text-fig. 1).

No. 6. On a very irregular substratum of *Porites* $27 \times 13 \times 25$ cm. high. One of the rough specimens above referred to. Otherwise it resembles No. 5, but the columellæ are more often compressed, and many calyces are almost round.

No. 8. On a low mound with undulating surface, $32 \times 20 \times 12$ cm. high. Again like No. 5, but calyces on the average larger, 3 mm. diameter being common; they are often round, and the columella is papillate.

No. 9. Substratum smooth, but the *Leptastrea* is roughened by exsert septa as in No. 6, which it resembles in other characters, except that the columellæ are broad and papillate as in No. 8, and also, as in this latter, they may be compressed to “*transversa*” type, in which case the papillæ are in a well-marked row, as in text-fig. 2.

No. 15. Rather irregular hump of *Porites*, $27 \times 15 \times 18$ cm. high. Surface of the *Leptastrea* somewhat roughened in places. Calyces small, generally 2 mm. in diameter up to 3 mm., some distorted, 3×2 mm. Septa: some exsert, distinctly granulated, entire, shouldered, sometimes swollen just before joining the columella. Ten, generally less, join the columella. Columella small, round; few papillæ or smooth on top, or compressed to a “transverse” partition, occasionally bearing a top plate.

The remaining two examples have a form of columella not hitherto definitely described. The row of papillæ noted in several of the above series fuses to a definite smooth plate lying along the top of the columella. This “top plate” has been noted as an occasional feature in specimens Nos. 4 and 15, but in the following it is found in nearly every calyx.

No. 7. This is the large specimen referred to on p. 365 and outlined in text-fig. 5. Calyces shown on Pl. V. fig. 10. The surface is smooth, the calyces on the sides regularly polygonal, to the naked eye appearing round. They differ markedly from the preceding in their shallowness and consequently sloping septa. The intercalycular lines are deep, but thecae cannot be said to be exsert. Average size of calyces 3 mm., but bands of much smaller size occupy shallow depressions. Shallow calyces of exceptional size are frequent, 4 cm. to 5×3 cm. On the upper surface the calyces are smaller, average 2 mm., deeper and less regular, i.e., more like the preceding series. Septa sloping, vertical or shouldered, according to the character of the calyx, always distinctly granulated and never toothed, generally thin, but some, on the top of the colony and the piece from

the spreading base, are thick. About 10 meet the columella, in large calyces up to 15; sometimes thickened just before meeting the columella. Columella: in all parts of the colony, both the cylindrical piece and the basal expansion with a top plate. Only a few are smooth, and in a few there is a row of unfused tubercles.

No. 16. This specimen was found in the dyke pool of the barrier edge, but is best considered in this series. It encrusts a loose stone on all sides, though the *Leptastrea* is dead underneath; measuring $15 \times 10 \times 6$ cm. high. Calyces regularly polygonal or round, slightly exsert, thus connecting the series with *L. immersa*. Diameters 2.5 to 3 mm., in depressions much smaller. Septa sloping, often shouldered, finely granular, always entire, very slightly exsert. Columella: (1) thick, with a few papillæ; (2) compressed; (3) absent but for overlap of septa; (4) well-developed top plate. (Pl. VIII. fig. 17.)

BARRIER EDGE SERIES.

The forty specimens from the barrier edge are all small, having grown in crannies of the lagoonward slope*. The largest is 16×12 cm., an average specimen about 10×7 cm. They are thus about four times the size of the largest of the inshore series, but very much smaller than the characteristic large colonies of the submerged flat, which, as stated, are often 60 cm. and may be a metre across.

Dividing by general facies,

30 specimens fall under *L. ehrenbergana*,
 6 " " *L. roissiana*,
 4 are not placed.

Even under the influence of the surf-floods the former have not developed the normal thickness of walls, which never exceeds 1.0 mm., and is generally only half this. The septa are very rarely thickened in the calyces and are never crowded. From Vaughan's definition of *L. purpurea* they differ in the absence or rarity of septal teeth, and in the fact that, when one or two teeth do occur immediately above the columella, there is no correlation between their presence and the granulation or smoothness of the septal faces and edges. There is not as much correspondence between septal thickness and columella density as would be expected.

The following descriptions give the evidence for the above statement:—

Facies *ehrenbergana*.

Of the 30 *ehrenbergana* specimens a group of 14 (more or less) is characterized by angularly polygonal calyces; only in two are more than a very few elongated. The larger are 3 to 4 mm. in greater diameter. The walls are thin, in eight specimens 0.5 to 0.75 mm., in four up to 1 mm., and in two only 0.3 to 0.5 mm. The calyces, being deep and open, emphasise this thinness of the walls, but the columella is, to the naked eye, large and solid. It is generally papillate, but may be trabecular, or solid and smooth on top. The septa are thick and granular near the theca, and may or may not be thin below and near the columella; their granulations may be coarse or fine, generally the former, but in any case toothing is rare and confined to immediately above the columella. From 12 to 15 septa meet the columella.

* All corals mentioned are from the lagoonward sloping flat. The top of the outer slope bears, as a rule, only stunted *Millepora* and *Pocillopora* in small quantities.

Another group of four specimens is characterized by more or fewer large calyces of nearly regular pentagonal shape, with sloping septa, of which up to 20 meet the columella. Nos. 22, 23, and 27 are described in detail, following which are a few examples which combine the characters of facies *purpurea* II. and *ehrenbergana* III. with *roissyana* and *transversa*, while being, on the whole, of the former facies.

No. 22. There are two groups of regularly polygonal calyces up to 10×10 mm., with numerous sloping septa, 20 meeting the columella, secondaries and tertiaries often fusing at inner ends in groups. They are thin, both on the theca and in the calyx. Primaries entire, or with one or two teeth just above the columella, secondaries and tertiaries often well toothed, but sides are nearly smooth. Columella dense, large papillate. These calyces are near to facies II., but there are also compressed calyces of facies III., with narrow vertical septa, not meeting before the columella, very rarely toothed (Pl. VII. fig. 14).

No. 37 is roughly dome-shaped, $8 \times 6 \times 4$ cm. high, in this and the (consequent?) regularity of the calyces resembling an inshore specimen. Walls 0.5 to 1.0 mm. thick. Septa steeply sloping, thick on theca, thin in calyces, or *vice versa*, nearly smooth, but often toothed above the columella, which is broad and papillate, but somewhat loosely made.

No. 23. Resembles No. 22 in having large facies II. calyces among those of facies III., but they are fewer and only 8 mm. across. Walls are only 0.5 mm. thick at most. The septa are thick and coarsely granular, more steeply sloping than in No. 22, practically always entire, though a very few have a tooth or two immediately above the columella. This is unique in all the collection in its size, one-third to one-half width of calyx, and in having a convex top which is packed with short rods.

No. 11. Colony, 10×5.5 cm., with unusually smooth outline and uniform calyces, which are, however, nearly all distorted. Walls usually less than 0.5 mm. thick, maximum 0.75 mm. Septa thick and granular, but very rarely toothed; being very narrow and vertical, the tops appear wedge-shaped. Columella large, dense, and closely papillate. (Form III.)

No. 33. Calyces mostly small, up to 4 mm. across, few are distorted. Septa, usually thin both on theca and in calyx, sometimes thick in calyx. Septa granular, entire, very rarely two or three teeth at the base. Columella of all kinds: (1) dense, papillate; (2) loose, papillate; (3) degenerate; (4) compressed, with papillae, as in *L. roissyana* of Vaughan's definition; (5) compressed, with three to six papillae in line, as in *L. transversa*. This specimen combines facies II., III., and IV.

No. 28. Walls 0.3 to 0.75 mm. thick. Calyces irregular polygons, some compressed, about 3 mm. Septa very narrow and thin, many broken, slightly granular or smooth, entire. Columella thick, papillate, or compressed to a thin plate with a few papillae in a single row. Degenerate *L. ehrenbergana*, combining facies III., IV., and VI.

No. 7. Similar to 28, but more stoutly built, more dense columellae, and fewer broken septa. May be considered as *L. ehrenbergana*, combining facies II., III., and IV.

Of the four unplaced specimens two, Nos. 26 and 12, have irregular calyces, two having small, regularly polygonal calyces.

No. 26. Calyces small, 2.5 to 3 mm., mostly regular polygons. Wall 0.5 to 1.0 mm. On the sheltered side of the colony small, nearly round calyces, with walls up to 1.25 mm. Septa always thin, nearly smooth, often broken between

columella and wall. Columellæ of every stage of development, dense papillate, loose and papillate, and quite degenerate.

No. 12. Calyces small, 3 mm. in diameter, distorted to 5 mm. long. Walls 0.5 mm. or less. Septa sloping or vertical, usually thin, some thicker, either on the theca or in the calyx. Columella degenerate, loosely trabecular, or made of overlapping septal ends, or almost absent. On the other hand it may be wide and solid, but with no definite structure.

No. 39. Calyces very slightly exsert, nearly round. Septa thin, smooth, entire, with dense papillate columella. Shouldering of septa, characteristic of *L. immersa* (found in many specimens), is prominent here (Pl. VIII. fig. 16).

No. 36 is similar, but the columella is looser, often with overlapping septa, rarely compressed.

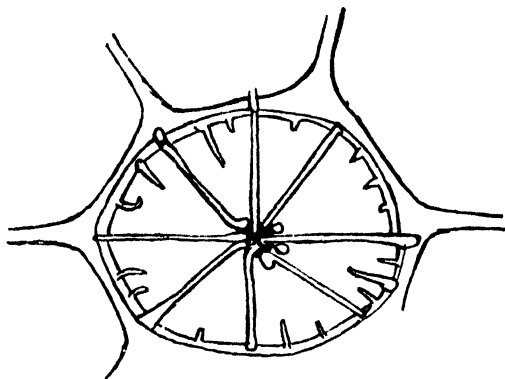
The last two specimens seem to combine the characters of *L. solida* and *L. immersa*.

The other specimens with uniformly small, usually regularly polygonal calyces have a general *L. roissiana* facies, but the columellæ and septa follow no definition.

Facies *roissiana*.

No. 8. A large colony for this habitat, 13 cm. across. Walls 0.5 to 1.0 mm. Calyces regular, often nearly round, about 3 mm. and up to 4 mm. In creases they are small, as usual. Septa regular, some very rough, or may be nearly

Text-figure 6.



Leptastrea, specimen No. 32, of the barrier edge series. A degenerate calyx showing columella formed by meeting of the swollen edges of the septa. $\times 15$.

smooth; shouldered, entire, some are thick in calyx. About 12 meet the columella. Columella: (1) dense papillate; (2) thick, but showing formation by overlap of septa; (3) same, showing the beginning of a *transversa* columella; (4) dense, but no papillæ. Few are slightly compressed.

No. 17. A small colony, 6 \times 4 cm. Walls 0.5 mm. Calyces average 3 \times 2 mm. being generally oblong, open, as septa are thin, narrow, and vertical. Septa roughly granular, but entire. 10 to 12 meet the columella. Columella compressed to a plate, or thick and papillate.

No. 31. 17 \times 11 cm. Calyces often nearly round, average diameter 3 mm., but may be 4.5 mm. Walls up to 0.75 mm. and 1.0 mm. Septa thin, slightly

granular, entire, shouldered, 10 usually meet columella, which is moderately thick, with papillæ, or compressed with papillæ in a single row.

No. 32. 11×5 cm. Walls usually 0.3 mm., rarely 0.5 mm. Calyces nearly round, 3 mm. Septa finely granulate, sometimes toothed at base, more often shouldered and entire, 10 or less meet the columella, which may be round and papillate, compressed, or reduced to overlapping septa (text-fig. 6).

No. 34. 15×10 cm. Calyces rather irregular, average 3 mm. Walls 0.25 to 1.0 mm., frequently the latter. The septa are swollen in the theca, also often well thickened in the calyx proximally, but the central parts are very thin and the columella is degenerate, but not compressed. It is formed by from six to eight septa. Septa nearly smooth or heavily granulated, practically always entire and shouldered.

No. 40. Like 34, but septa thin; they may be smooth or granular.

Genus LOBOPHYLLIA. (Pls. IX.-XII. and text-figs. 7-10.)

Occurrence and Ecology.

As noted in my account of the Tahitian coral fauna published in the P. Z. S. in September 1928, *Lobophyllia* is one of the common corals of the Red Sea, where it usually grows in dome-shaped masses 6 feet or more in diameter. As its stems are unprotected from boring organisms, the interior is generally more or less rotten. Most colonies are to some extent broken down, some of the branches scattered on the bottom, where they continue to live for a short time. In Tahiti the genus is rare, but long search in the Pa'ea lagoon has yielded 24 specimens, only one of which attains normal proportions, being a dome 4 feet high and 6 feet in diameter (No. 22). The majority are small, like those seen in 1925-6, ten being under 20 cm. in diameter, ten more do not exceed 60 cm., and three are a metre or nearly across. Their colour is often the greyish tint noted in the 1925-6 specimens, but more usually a yellow-brown, sometimes radially banded with a lighter tint, deepening on the circumoral disc. The expanded tentacles are slender and colourless, about 10 mm. long. As usual in the *Astreans*, the lower, shaded polyps are of a deep chocolate-brown all over; the bright green circumoral disc noted by other observers is present in only two colonies (Nos. 12 and 14) and, as in the case of *Favia versipora*, there seems to no connection between this brilliant colour and any skeletal or ecological variation.

All but four of these specimens are from the submerged flat beyond the lagoon channel, where, like all but three genera, it is unable to grow directly on the bottom, but is found attached to *Porites* or, in one case each, to *Montipora*. and *Millepora*. The larger colonies are on the sides of the supporting coral, the best developed on the north side facing the current, which is constantly southward. The big dome (No. 22 referred to) appears to be an exception; but, half of it having collapsed, a core, presumably *Porites*, was exposed. Many colonies are excessively rotten within, and many can be taken up only in fragments, which it is often impossible to fit together again, several are completely hollow underneath, and hang together literally "by the skin of their teeth," aided by slight growths of sponge between their stems.

Of the three specimens which were found in other habitats, No. 8 grew in a cranny of the shore reef, but on its outermost point, where it is swept by the current passing through a construction of the channel leading to the broad lagoon of Maraa; No. 7 is the only specimen ever seen on the barrier edge, and No. 14 is from a pool, held up by a dyke, immediately within the raised edge. The genus has never been seen on the ocean slope.

These barrier specimens are modified by their exposure to the surge in an unexpected way. Both show conspicuously deep, broad, calyces with delicate walls, thin narrow septa closely placed, so that the difference between major and minor septa is less conspicuous than usual, and the calyx is widely open. Most of the septa are finely toothed, as is the rule where they are narrow. The colonies have, therefore, a slight and delicate appearance, the more marked in the specimen from the actual barrier edge, which has quite a flower-like appearance, in spite of the wild surges to which it was exposed (Pl. IX. fig. 19). On cutting into the theca it is found to be only 3 mm. thick at the level of the columella, but solidly made in both specimens, and in No. 7 the septa and dissepiments thicken to form a nearly solid mass, the weight of the small stock being immediately noticed on taking the specimen into the hand. No other specimen, not even No. 14, from the dyke pool, shows this special development of the stock.

SYSTEMATIC.

It is significant that all the three species into which Matthai divides this genus are found throughout the extreme limits of the Indo-Pacific area, viz., from the Red Sea to Tahiti. (It is not, as yet, recorded from the Tuamotu Atolls, and the easternmost islands, the Marquesas, have few genera, among which this does not occur.)

It is clear from Matthai's catalogue that no normally well-grown specimen exists in any museum of Europe or America; indeed, the difficulties of collection, conveyance, and, finally, storage make it impossible that there should be. Of the 58 foreign specimens which Matthai considers in detail (he examined 211 altogether), only five are 20 cm. or over in major diameter, the rest can only be described as scraps, or are dwarf colonies, such as grow in crannies in very shallow water. Compare his side views with mine on Pls. X. & XII. and text-fig. 7. The specimens collected by Dana were stunted, even for Tahiti!

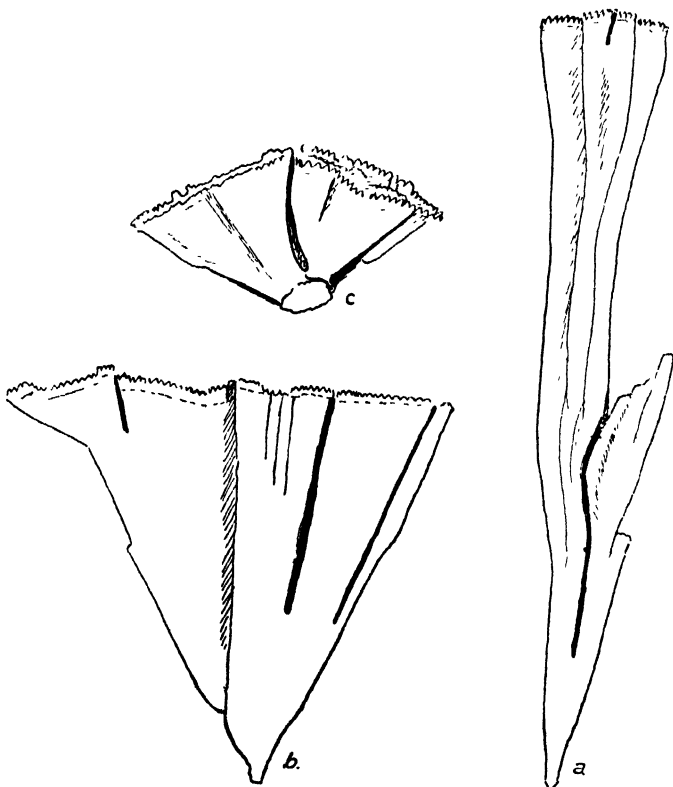
The only way in which specimens of normal size could be represented in a museum would be for a collector who had some knowledge of coral species to examine a series of colonies by means of a diving-hood, measuring-tape and compass in hand, taking samples from defined positions, and, even so, the museum would need to be liberal as regards freight and storage. As things are, a museum collection gives little idea of the large growths abundant on all reefs, and the well-known existence of large variations in the calyces, with their position in the colony, is probably not known in many such large corals; the large specimen of *Turbinaria* in the British Museum described by Jeffrey Bell is a notable exception.

Though Matthai describes only the type-specimens in detail, a small proportion of the 211 specimens which he examined, these are enough to show the immense variability of all the species. I have attempted to show the variability of those of my specimens which fall into these species numerically in the table, in which each line represents 20-40 measurements, or counts, according to the size of the specimen, the thick lines indicating the measure most frequently found, the thin those commonly, the dots those rarely, occurring. The vertical lines of dashes include the measures given by Matthai in his definitions of the species, so that the variations therefrom of these Tahitian specimens may be compared at a glance. Following Matthai, I have divided my specimens in the first place by the degree to which the formation of meandrine valleys has proceeded. In *L. corymbosa* the majority of the calyces are monostomodæal, and the valleys do not exceed 60 mm., though some specimens are included

in which there is a slight excess. In *L. costata* mono- to tristomodæal calyces are rare, and valleys up to 120 mm. occur. Again I find much longer valleys occasionally, as will be described below. *L. hemprichii* is wholly meandrine. has broad, deep calyces, exsert parts of septa broadly arching, with broad-blunt teeth conspicuous even beneath the retracted polyp flesh. The connecting lamellæ are more numerous usually than in the other species.

I find that of my 24 specimens, *L. corymbosa* accounts for seven, *L. costata*

Text-figure 7.



Lobophyllia. Three forms of growth from the large colony, specimen No. 22. $\times \frac{1}{15}$.

a. Calyces remain short, forming a stick-like branch.

b. A short calyx at the base broadens out into long narrow valleys, forming a triangular plate.

Compare Pl. XII. fig. 24.

c. A conical growth, hardly distinguishable from *L. hemprichii*.

(All three are $\times \frac{1}{15}$).

for five, and *L. hemprichii* for five. Of the remaining seven, two are specially modified by the reef-edge environment as described above, and five are intermediate between two species.

The table shows that no other characters vary constantly with that of valley formation, and that, indeed, no set of characters exists upon which specific definition can be founded. The septal teeth, usually of systematic importance, fail us completely; in practically all specimens the major septa may bear

many small saw-like teeth, or a few large blunt ones near their bases, or none at all except on the exsert portion, where again variability is great. There is, however, a definite rule in the matter of teeth within the calyx; a broad septum, standing well in towards the centre of the calyx, is toothless, those of the usual position bear three to five blunt teeth in the lower part, while others, equally exsert, and distinctly of the major class, are narrow, and bear a number of small saw-like teeth, through most of their length, like the minor septa. It is a matter of mechanics, and illustrates again that these teeth are formed by reduced, not by more active, growth.

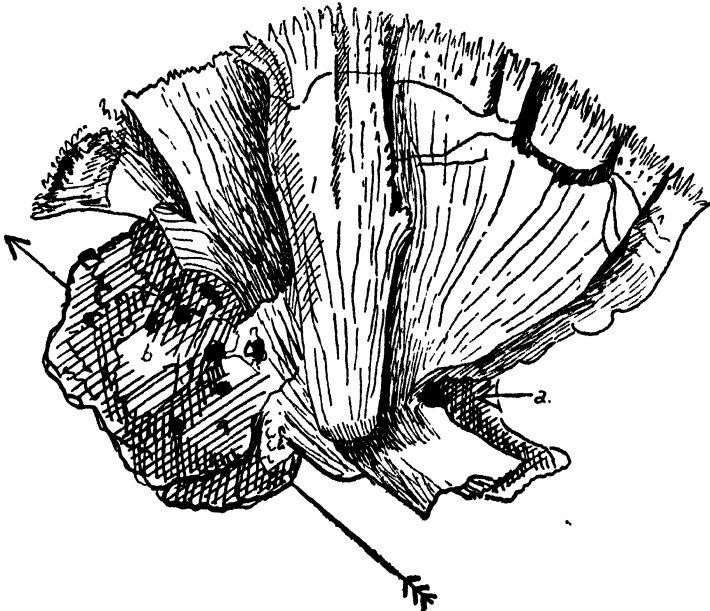
That changes in the development of valleys are undergone during growth is well seen in the side views of many specimens. Since the edge zone of the polyp extends only a short distance down the stem, there is no filling in between the calyces in the older parts of the colony, and a broad stem was originally a long valley, whether it continues as such, becomes longer, or breaks up into a series of short *corymbosa* calyces. Pl. X. fig. 21 illustrates the simplest growth-form, a short valley at the base having given rise to a number of similar *corymbosa* calyces as it grew. In the large colony (No. 22) such short valleys may continue indefinitely, forming the stick-like forms of text-fig. 7, which are up to 76 cm. in length. On the other hand, a round, or nearly round, calyx may expand into the triangular shapes shown alongside, supporting long, narrow valleys such as that illustrated on Pl. XII.; the reverse case, where a long valley has been formed in this way, and later breaks up into separate calyces, is common, and is illustrated by text-fig. 8.

In the calyces there are certain variations which have escaped notice hitherto; their dependence on their surroundings will clearly emerge. These are: (1) The formation of broad, plate-like stems bearing disproportionately long and narrow valleys along their upper edges; (2) wholly meandrine colonies, or parts of colonies, which cannot be classed as *hemprichii*, since the valleys are narrow and without any of the other characteristic features of this form. Examples of the former are to be found in many specimens of both *corymbosa* and *costata*. In specimen 13 several were collected, of which the largest bears two valleys, 150 and 130 mm. long; another bears a single valley, 300 mm. long, the triangular plates having a greatest depth of 220 mm.. Both are 10 to 20 mm. thick, the average being 15 mm. (Pl. XII. fig. 24 and text-fig. 7). In specimen 22, the largest found in Tahiti, the examples collected are three large plates: (1) 50 cm. wide and 34 cm. deep, valley 300 mm. long; (2) 36×37 cm., valley 295 mm.; (3) 28×36 cm., valley 175 mm. The widths of the valleys average 15 and 20 mm. The plates thicken at one end, where they bear short meanders and mono-tristomodæal calyces. Their triangular shape shows that they arose by the modification of a normal short calyx (text-fig. 7).

Specimen 19, a metre in diameter, grew as a flat cake on the top of a hollow mass of *Porites*, and could therefore be examined and drawn *in situ*. The sketch is reproduced as text-fig. 9, and shows the position of the samples taken ashore, of variations in the development of the calyces, and of several long, straight valleys similar to the above. These lie in shallow depressions of the surface of the colony, and are obviously due to crowding between more vigorously growing areas. Piece 2 contains straight valleys with lengths up to 150 mm., breadths only 10 to 20 mm., the rest of the piece being wholly meandrine, yet in every other respect wholly distinct from *hemprichii*. Piece 3 is composed of a complicated meander, branched on both sides, very like colony 17 (illustrated on Pl. XI.); the main valley is 160 mm. long, with a second of 70 mm. These are on the whole broader than in piece 2, but do not exceed 20 mm. In both cases the abnormality is the result of crowding: in the case of piece 2

between the growing colony and dead coral; in piece 3 by the coral having grown out through a cranny in dead corals. The rest of this large colony is of typical *costata* form, including piece 1, which has, however, some valleys up to 150 mm. Specimen 17 affords an equally striking example; this is a whole colony, 17×9 cm. in area, almost exactly similar to piece 3 of No. 19. It is shown on Pl. XI. fig. 22. It grew in a cup-shaped hollow in the top of a *Porites* mass, which it fitted exactly in the horizontal directions, but without reaching quite to the top of the cup.

Text-figure 8.



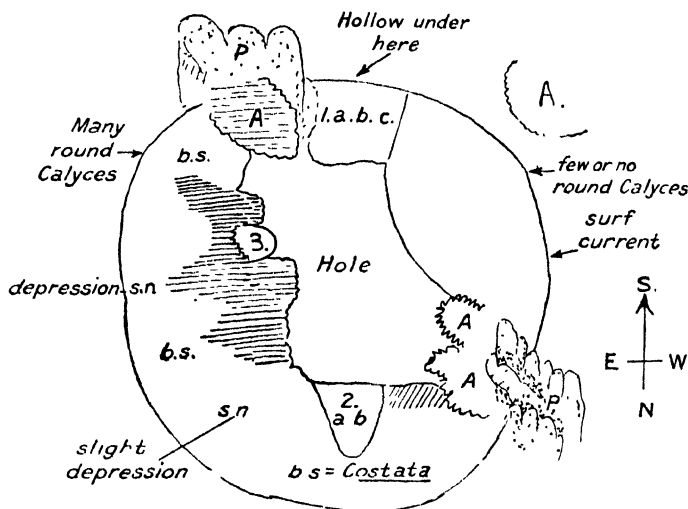
Side view of *Lobophyllia*, specimen No. 5'2. $\times \frac{1}{2}$. Showing the formation of two overlapping plates from originally short calyces, as a result of deflection of growth. The original direction of growth is given by the arrow. At their upper edges the stems bore valleys 110 mm. and 120 mm. long, but are now reverting to the short valleys of the original *corymbosa* form. Compare the photograph of the upper surface (Pl. X. fig. 20), which shows that the part to the left and behind retains *costata* valleys.

- a. Point at which deflection occurred.
- b. A mass of dead coral, with *Porolithon*, and *Vermetus* tubes, probably concerned in the deflection.

Specimen 16 shows the first stage in this formation of narrow valleys. It is a large example, 60×38 cm., of the shape shown in text-fig. 10. It grew on the side of a mass of *Porites*, its lower edge well above the bottom; the two sides of the colony and its lower edge bulge out and cause a depression in the centre of the upper edge. The three areas indicated were separately measured, and the results are shown in the table, in which the effect of compression is clearly shown.

This formation of long, narrow, more or less straight, or completely median valleys is often accompanied by what may be called the *cytherea* arrangement of the septa, as it is shown in Dana's type so named, collected in Tahiti

Text-figure 9.



Lobophyllia, specimen No. 19, *in situ*, as sketched from a canoe, showing variation with position and surroundings. \times about $\frac{1}{4}$.

1, a, b, c; 2 a, b; and 3 are the six pieces taken ashore and examined in detail

A, A. Colonies of corymbose *Acropora* sp.

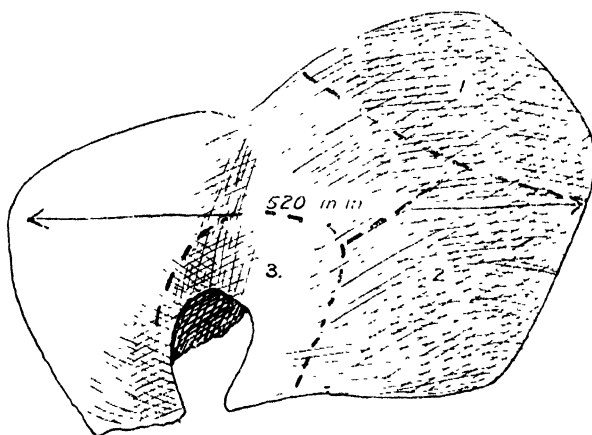
P, P. Parts of the supporting colony of *Porites*.

s.n. Straight narrow valleys in the *Lobophyllia*.

b.s. Short broad valleys of the *costata* type.

(Dead areas are shaded.)

Text-figure 10.



Lobophyllia, specimen No. 16. To show the shape assumed by the colony and the positions of the three areas, the measurements of the calyces of which are given in the table. Note that area No. 1 was on the lower edge in life.

82 years ago. Vaughan gives a photograph (1918, pl. 49, fig. 3) and remarks (p. 123): "At one time I thought the latter separable from *Mussa sinuosa*" (now *Lobophyllia costata*) "by its narrower valley and the usual absence of prominent dentations on the lower parts of the margins of the lower septa, but, as such dentations are sometimes present, there is no break between it and *M. costata*. The development of the septal teeth on the lower margins of the principal septa appears to be correlated with the width of the valleys." For the last word, "valleys," I have found it necessary to substitute "septa," otherwise my specimens agree with Vaughan's result. Dana's specimen is the most generalized of the set to which I propose to allot this name, but it shares one of their most striking features, viz., the wide spacing of the broad, square-ended, major septa, which may be 5 to 10 mm. apart, and include between them small septa in sets of three to six; in the latter case some of the minor septa are enlarged, and may represent an intermediate cycle. Such a case is illustrated on Pl. XI. The columellæ may be distinct, or the connecting lamellæ may be trabecular, giving a diffused appearance to the row of columellæ.

The occurrence of longer meanders than the normal may, on the other hand, result from exactly the reverse condition, viz., the freeing of short calyces for lateral expansion by growth above an obstruction, or by an accident to their neighbours. Valleys so produced are broad, and readily distinguished from those described above. The first stage is an eversion of the calyces, with specially prominent costal spines, such as is illustrated on Pl. XII. fig. 23, which occurred naturally in specimens 1 and 22, but has been also produced experimentally. In other parts of the specimen illustrated (No. 1) and in other specimens, such as Nos. 5 and 15, these eversions have grown into valleys. Of No. 5, the larger portion, measuring 30×19 cm., is shown in text-fig. 8 and Pl. X. fig. 20. It may be divided into two parts, in one of which the stems are more or less straight for a depth of 10 to 16 cm.; in the other they are straight for only 3 or 4 cm., at which stage of the growth of the colony an accident caused a diversion. The corresponding difference on the surface of the colony, shown on Pl. X. fig. 20, is that, while the former clearly falls under *corymbosa*, having 13 calyces monostomodæal, 5 di- and 2 tristomodæal, the latter is mainly occupied by two meanders and their branches with 1 mono-, 1 di-, and 4 tristomodæal calyces in addition, and therefore must be classed as *costata*. The smaller portion of this colony, 11×10 cm., is a single meander, the average width of its valley being 15 mm. No. 15, the smaller piece, 22×16 cm., almost reproduces the accident and re-growth of No. 5; but this has not involved any change on the surface, which is made up of mono- to tristomodæal calyces, the longest valleys being 55 and 70 mm. long. It is therefore a *corymbosa*, except for the fact that over part of its area the major septa are usually 2 mm. thick, a characteristic of *costata*, but a rare occurrence in the whole of this series. On the larger piece of the same colony, 40×30 cm., the greater part is again *corymbosa*, but an area 17×19 cm. to one side has resulted from an outgrowth almost at right angles to the main stems, and this is almost wholly meandrine, with valleys 25 mm. across, one of them (without its branches, of course) 155 mm. long; these valleys have the other characters of *hemprichii*.

In general, as exemplified already in specimen 16, the calyces of the lower part of the colony are the larger, and lead on to the *hemprichii* form. The meandrine condition is here due not at all to crowding—as stated, the lower margins of the colonies are usually above the bottom—but to exuberance of growth, and the five specimens classed as purely *hemprichii* were not found in restricted habitats.

Enough has been described to show that conditions alone lead to growth-

forms as widely different as the three species, and indistinguishable from them.

To recapitulate from the purely systematic point of view, we have :—

Specimen 1. *corymbosa costata*, six pieces collected, four with delicate stems and small delicate calyces, as Pl. XII. fig. 23, already referred to ; two are plates, with eight or nine columellæ, 100 mm. long. One of these, with another piece made of short valleys, were submitted to Professor Vaughan, who identified them as *costata*.

Specimen 5. *corymbosa-costata-cytherea*, as above (text-fig. 8 and Pl. X. fig. 20).

Specimen 6. Classed wholly under *corymbosa*, yet striking differences between two areas of the colony are shown in the table of measurements.

Specimen 14. Intermediate between *costata* and *hemprichii* (see table).

Specimen 15.1 is *corymbosa*, with septa as thick as in *costata* (Matthai's definition, that is, septa 2 mm. thick, are rare in the Tahitian series) over one part of its area. Specimen 15.2 is *corymbosa-hemprichii*.

Specimen 16. *costata*, but approaches *hemprichii* along its lower border.

Specimen 22. *costata* ; parts are *cytherea*, parts *hemprichii*. Approach to *corymbosa*, since mono- to tristomodæal calyces are common in places (text-fig. 7).

The table of measurements (Pl. XXII.) shows that the five *hemprichii* specimens form a more distinct group than do the others ; but all the differences between *costata* and *hemprichii* are clearly to be ascribed to an exuberance of growth of the former.

The thecal walls of Astreans are formed by the septa (Matthai, 1914, p. 35), a fact which, in these huge calyces, it is easy to demonstrate with a simple lens. It is therefore not surprising that when the septa are abnormally exsert the calyces are shallow. The most constant feature of this series is the exsertion of the major septa to 5 mm., and where this is exceeded, in some of the *cytherea* specimens, the difference is due, not to addition to the septa, but to a partial failure to build the theca between them, as shown by the occurrence of half-formed walls in some cases. That the majority of the series show building-power below the normal is shown at a glance by the table of measurements. The best measurable index is the thickness of the major septa, since all other structures of the calyx are intimately connected, structurally and ontogenetically, with them. In few specimens does this commonly reach 2 mm., the thickness given by Matthai as normal for *costata* and frequent in *hemprichii*, and in part only of one specimen is this normally the case. The usual thicknesses of the walls are given as 4 to 5 mm., with a maximum of 6 mm. for *corymbosa* and *costata*, and up to 6 or 7 mm. for *hemprichii* ; exceptions are given, but few in proportion to the great number examined. Matthai does not state how these thicknesses were measured ; the numbers given here were obtained by cutting across the wall at, or immediately above, the level of the columella. In the *corymbosa* specimens, out of 43 measurements there are only seven of 4 to 5 mm., the other 36 being 2 to 3 mm., and five are less than 1 mm. In four *corymbosa-costata* intermediates, of 3¹ measurements, six are of 4 to 5 mm., three of 7 mm., the remaining 22 of 2 and 3 mm. In five *costata* specimens 56 cuts were made, revealing thicknesses of 4 to 5 mm. in 13 cases, the other 43 being of the usual 2 and 3 mm. One specimen of *hemprichii* was cut (No. 21), walls of 3, 4, and 5 mm. being found. These were all solid, whereas the thicker walls of the preceding measurements, with two exceptions, are hollow and even spongy. In the simplest cases the theca is nothing but a series of narrow fusions of lateral swellings of the septa (to which may be added, outside, a thin secretion of the edge zone, and, within, one to three

dissepiments, generally also very thin ; the septa are seen running through all these accessory structures, but in some cases these are laid down more solidly, and the wall contains but a few small spaces as relics of its compound origin

This lightness of build affords an explanation of the almost entire absence of large colonies in Tahiti, though it has nothing to do with the small sizes of the other *Astreans*. As noted, even in the Red Sea the colonies are often partly broken down through decay of their lower stems ; here this process is even more easily accomplished, and the larger colonies have completely rotted away within. Of the single large colony (No. 22), half has broken down, in spite of the fact that my cuts in the walls show none less than 3 mm. thick, and those solidly made.

According to the rules of nomenclature, this single-species genus must be called *Lobophyllia corymbosa* Forskål, 1775 ; but it is impossible to dispense with the other two names assigned by Matthai, nor do I find any other necessary except the *cytherea* suggested above. Would this conclusion have been reached if this work had been done beside a richer coral sea, in which the *Astreans* attain normal numbers and growth ? In other words, is the variability greater, while the growth is less, round this far oceanic island ? This can only be decided by completing a systematic examination in some such area ; but Matthai's result, depending though it did on chance collections, strongly predisposes to the idea that quite a different result would have been attained, and conclusions reached in accordance with his own.

Genus FAVIA.

I follow Matthai in including the genera *Orbicella*, *Favites*, and *Acanthastrea* in this genus :—

(1) *Orbicella* contains a group of species distinguished by their round calyces, which multiply by budding. It might be a convenience to use a subgeneric name for the group, but *Orbicella* is not available, being preoccupied by the West Indian *O. annularis*, which, having directive mesenteries, cannot be of the same genus as these Indo-Pacific species, which have none. Also, in Tahiti at any rate, all the three species described by Matthai are variations of one, to which I add a second, *Favia ingolfi*, and to designate two species as a subgenus is causing greater confusion than simplification. At the same time these two species, in their Tahitian varieties, show a connection with such genera as *Echinopora* and *Leptastrea*, and, in fact, species and varieties of *Leptastrea* have frequently been included under the name *Orbicella*.

(2) *Favites* and *Acanthastrea* are united under *Favia* because the species *F. hemprichii* and *F. complanata*, though, I believe, distinct, are very closely allied ; but, if these generic names are retained, *F. complanata* is a *Favites* and *F. hemprichii* an *Acanthastrea*. They are so placed on Vaughan's rearrangement of Matthai's genus *Favia* (1918, p. 101), but the separation is unnatural.

1. FAVIA STELLIGERA Dana. (Pls. XIII. & XIV. and text-figs. 11-13.)

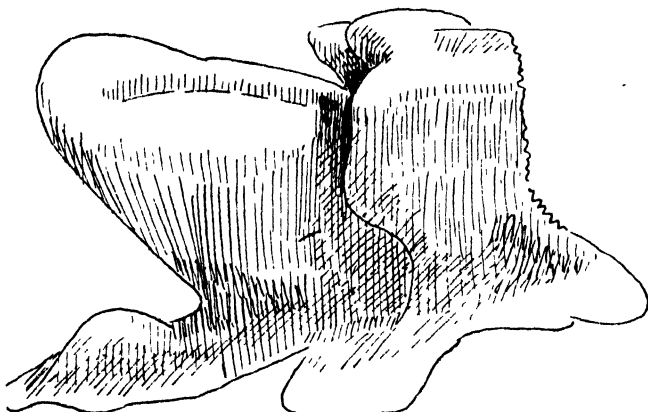
The name *stelligera* is substituted by Vaughan, and for the *acropora* used by Matthai Vaughan states that "for reasons stated the name *acropora* is not available for any coral."

We have here a species with little variation which is easily determined. It is rare in Tahiti ; but, out on the reefs, is readily distinguished from the common *F. versipora*, in spite of being the same colour, generally the same size, and occupying the same habitat, by its two characteristic features, viz., its

growth-form, hillocks which decrease in thickness below their summits, and its small, often irregularly-shaped calyces. It is remarkable that the mere growth-form should be always characteristic; text-figs. 11-13 show that it is retained under all conditions. Seven of my nine specimens resemble the three of Mayor's Samoan collection in being small and simple, though they cannot be described as cylindrical; of these, six are surf-affected specimens from the lagoonward slope of the barrier edge, or the tops of *Porites* blocks immediately within it (text-fig. 11); one is from 4 feet of water immediately within the edge (text-fig. 12). All these show distinctly the characteristic broadening of the tops of the hillocks, though the columns of larger and more characteristic specimens are not formed. These are well developed in the eighth and ninth specimens, which are large, one being the largest Astrean seen (except some specimens of *Lobophyllia*), as it measures $120 \times 100 \times 40$ cm. deep. Such columns are shown in text-fig. 13 and on Pl. XIII. fig. 25.

The species is normally characterized by variations in the direction of

Text-figure 11.



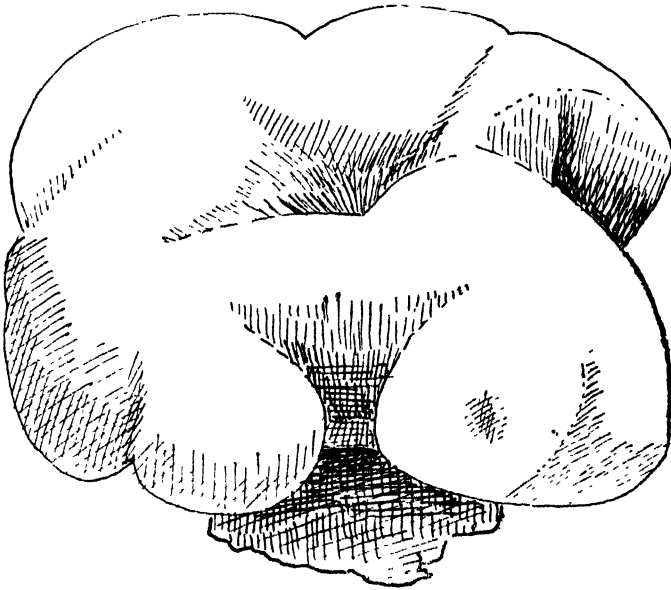
Favia stelligera. A barrier edge specimen (No. 1) to show the characteristic broadening of the top of the colony. This colony was attached to the reef by its right side as well as below. $\times \frac{3}{4}$.

reduced building-power, *e.g.*, Matthai says: "Peritheca vesicular or compact, columella varying in texture, being compact or spongy, one-fifth to one-half the width of the calyx, in some corallites quite rudimentary." The pali are generally few and slender. Vaughan notes "there is a wide range in variation of the thickness of the septa and costæ; they may be thick, or thin and fragile in the same specimen." It is by the examination of the figures of both authors, rather than from their text, that it is seen that the degenerative changes referred to are the exception in the specimens they examined, but the rule in the Tahitian; this evidence is clear, since Matthai gives four photographs and Vaughan nine. Vaughan also describes briefly a var. *fanningensis*, characterized by its light texture, the ragged margins of the thin septa, and lax, weakly-developed columella, characteristics all my Tahitian specimens, in which further degeneration is often found.

There are large differences between the corallites of the upper surface and the sides and bases of each corallum, and these differences are constant throughout the series (compare figs. 26 & 27 on Pls. XIII. & XIV.). The calyces

of the upper surface are less regular in shape, more closely placed (they may be only 0.25 mm. apart, and even less), and, above all, more delicate in structure than those below *, which are less exsert, larger, rounder, shallower, and more widely separated, usually 1.0 mm. or more, and generally more normal in structure. The first peculiarity of the Tahitian series is to be seen in the septa and costæ (Pl. XIII. fig. 26), which are practically always so thin as to appear translucent: an appearance of thickening is sometimes due to bending of the free edge. They are peculiarly spinulose and ragged, sometimes dissected on their well-exsert edges, which, on the upper surfaces of the corallum, are usually square-cut. Within the calyx they are narrow, broadening below into shoulders, which in most cases are the only representatives of the palial lobes, below which they are dissected into long trabeculæ. Where the pali

Text-figure 12.



Pavona stelligera, specimen No. 5, from 4 feet of water, with lobed form. $\times 3$.

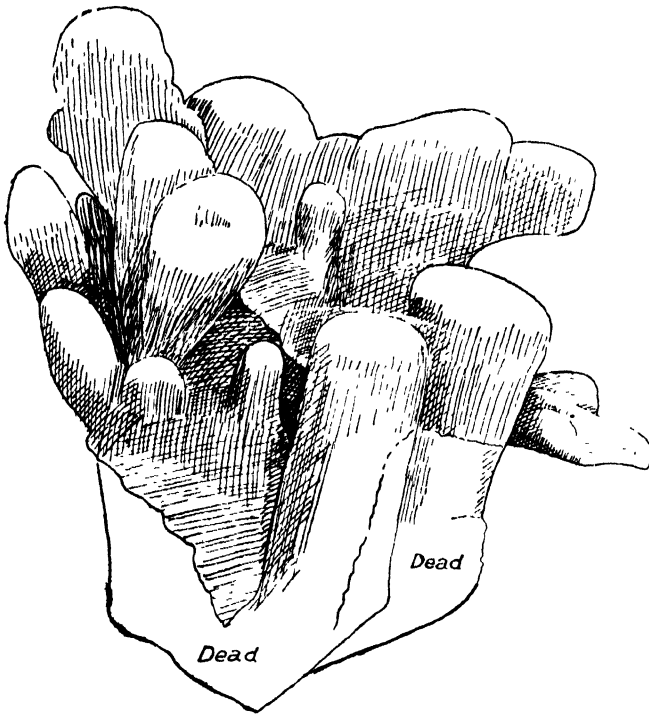
are distinct they are slender and spinulose. It is characteristic of the species for the calyx to be shallow, but those of the upper surface are deep, especially when the columella is absent, or represented by a few thin trabeculæ. Where the calyces are crowded, i. e., over most of the upper surfaces, the costæ often meet, and may be quite continuous between septa of adjacent calyces. In such cases they often connected by transverse spines, like the synaptacula of Fungiidae, and when, in folds between columns, the thecæ disappear, the resemblance to one of the forms of *Pavona maldivensis* is striking. On the inward sloping sides of the coralla and on their spreading bases the septa are thicker, though clearly less so than in the specimens illustrated by Matthai and Vaughan, less exsert and regularly arched, and the costæ do not cross the wider spaces between the corallites. The pali are distinct, 5 to 12 in number, and the columella is low but compact. In one specimen the calyces of the sides

* As usual in many corals.

are larger and shallow, up to 3 mm. in diameter, but there are rarely any distinct pali, while the columellæ are broad, at one end of the colony compact, towards the other trabecular, and finally they become hypertrophied, a granular opaque mass occupying half the calyces, involving some of the septa and projecting above the thecal wall.

One specimen which grew in 4 feet of water (text-fig. 12) LWS, and from its regular shape may be presumed to have been unaffected by surf, shows no difference to the others except that the calyces of the upper surface are about 1 mm. apart, and therefore the costæ do not often meet, but some are continuous from calyx to calyx and some are connected by the transverse spines

Text-figure 13.



Favia stelligera. Part of a large colony, specimen No. 9, with typical columns.
Coral pool just within the barrier edge. \times about $\frac{1}{2}$.

noted above. The thecal rims are, as usual, very thin, and the pali are delicate and ill defined even on the sloping under surfaces.

The larger specimens have the usual thin-walled delicate calyces with degenerate structure on the upper surfaces of all their columns, but the greatest peculiarity is in the calyces of those faces of the columns which are enclosed by their neighbours from the free circulation of the water (Pl. XIV. fig 27). They are well separated and deep, but only 2 mm. or less in diameter, the septa so narrow that the calyces are left quite open but for a large, irregular, but generally dense columella, which rises from the floor with no support from the septa, which either fail to reach it at all or may do so in two or three cases only.

In some cases septa and columella are mixed indistinguishably in a spongy mass of trabeculae which nearly fills the calyx. On the fronts of the columns the calyces resemble those of the upper surfaces, deep with all the septa thin, columella irregular but supported by the septa; pali 0-3-5 in number. In creases between the knolls the septa may be so narrow that the calyces appear tubular and empty but for the top of a long spine or a few thin trabeculae.

Six of the specimens have their calyces on the upper surface similar to the photograph, but the walls are slightly thicker in a few columns. The septa are *all* very thin, but may be more spinulose; the columella is the same in three specimens, less developed in three others, while pali are equally well developed in three specimens, less so in three others, better in part of one. It may be noted that this greater delicacy and crowding of thecae on the tops of the columns is also characteristic of surf-swept specimens of *Pocillopora*? *verrucosa*, well shown in Hoffmeister's figures of Setchell's specimens from the Tahitian barrier edge.

2. *FAVIA VERSIPORA* Lmk., 1816. (Pls. XV.-XVIII. and Pl. XIX. fig. 32.)

Synonymy: *Orbicella curta* Dana, 1846.

Astrea solidior M.-E. & H., 1850.

Orbicella wakayana Gardiner, 1899.

Favia versipora Matthai, 1914.

F. wakayana Matthai, 1914.

F. solidior Matthai, 1914.

This is the commonest *Astrean* in Tahiti except *Leptastrea*, occurring frequently on the lagoonward slope of the barrier edge, more rarely on the inner part of the submerged flat, but seen once only on the shore-reef of Pa'ea. I have seen it frequently on the ocean slope of the reef, but have not secured specimens from this habitat. The colonies are always small (with one exception), $14 \times 11 \times 10$ cm. high being large, half of each of these measures being a fair average size. One exceptional colony is equivalent to seven of ordinary size, consisting of six large and two small cushion-shaped areas, which together make up an irregular inverted cone, 29×27 cm. across the top and 23 cm. high; nearly half the top and half or more of one side was dead. In life the colonies are light brown to almost white; the polyps of some specimens have conspicuous light or dark green discs; but, as in *Lobophyllia*, this colour-variation does not accompany any difference in the skeleton.

SYSTEMATIC.

Concerning *F. wakayana*, Matthai remarks: "Probably already recorded by Dana, but it is not possible to say until his types have been re-examined." This has been done by Vaughan (1918), who finds that his *Orbicella curta* from Fiji and his *O. coronata* from Tahiti are the same species as Gardiner's *F. wakayana*. Vaughan publishes photographs of these types (1918, pl. 28, figs. 4 & 4 a) of which the Tahitian specimen is unlike mine in having pali fairly well developed. Perhaps as "Tahiti," in the list of specimens on p. 68, includes Flint Island, in the Manihiki Group, more than 6° north of Tahiti, Dana's specimen was not really from this island.

According to Matthai, the three species *versipora*, *wakayana*, and *solidior* form a regular series, the sizes of the calyces, in breadth and depth, the amount by which they are exsert, the number and thickness of the septa, and their

exsertness all forming an ascending scale. *F. versipora* is encrusting. *F. wakayana* usually encrusting but sometimes massive, *F. solidior* encrusting. Of the 60 specimens I have examined only nine are encrusting, though many resemble crusts through parts of the colonies being dead, especially the upper surfaces of semi-cylindrical colonies.

I am unable to separate my specimens into species, though the photographs I give show that variation is wide enough to include all three. Compare, e. g., the two photographs on Pl. XV. of *F. curta* (*wakayana*) and *F. solidior*, which are, in fact, two sides of the same globular colony. Not only is the size of the calyces different, but, in the larger, the greater thickness and prominence of certain septa, a characteristic feature of *F. solidior*, is well shown. The rule given for *F. stelligera* holds here also, viz., that the calyces of upper, exposed surfaces are smaller, crowded, with thinner walls and septa, those of the vertical face larger and more separated, on the exposed side more exsert; on a confined face still more widely separated, hardly exsert, and shallow. Since *F. versipora*, in the majority of cases, grows attached to the side of its support, and the upper calyces are frequently killed except for a band round the edge, the rule is not so clearly demonstrated as in the free columns of *F. stelligera*. It is unfortunate that we are not told from what part of the colonies the photographs published were taken.

Besides this individual variation is that due to habitat. Specimens growing in the complete shelter of the lagoon, especially as crusts on vertical faces or in crannies of *Porites*, show the form which the above considerations would lead us to expect, but exaggerated, viz., large calyces 5 mm. and over in diameter, thin walls and thin narrow septa, which leave the calyces more open than is usual even in Tahitian specimens (Pl. XVI. fig. 30). In spite of the large calyces, there is no approach to the other characters of *F. curta* or *F. solidior*. Divided by the average sizes of the calyces, in spite of the great variation in every colony, my 60 specimens might be divided thus: *versipora* group 14 specimens, *curta* 34, and *solidior* 12.

The septa are always thin, thus removing another of the distinctions between *F. versipora* and the other two species, but the special prominence of a few septa, characteristic of *F. curta*, and especially of *F. solidior* (shown in fig. 28 of Pl. XV.) can be made out in 16 specimens, and is conspicuous in six others, though it may be present only in one part of a specimen, or visible only in odd calyces.

Specific differentiation is made still more difficult by the degeneration characteristic of the Tahitian Astreans, which is most general in this, the commonest species. The calyces are generally deep, through the columella being low; the narrow vertical septa are cut into long trabecular teeth in their lower halves; these increase in length until their ends meet, and twist, in the usual clockwise direction, to form the more or less loose columella as shown in fig. 32 of Pl. XIX. In some specimens the columella is absent (Pl. XVIII. figs. 33 & 34). In vertical section this looseness of the columella is seen to persist throughout its length (Pl. XVII. fig. 36). The palial lobes, so conspicuous in the 17 published figures*, are altogether absent in the great majority; I find indications of them in eight out of 60, and in these they are confined to a few calyces of each, and in all but three specimens they are quite rudimentary, being merely the upturned ends of some of the longer septal trabeculae, with no thickening except, in some cases, added granulations at the point. Curiously,

* Matthai gives eight figures (in two of which the interior of the calyces is not visible), Gardiner five, Vaughan five, and Mayor one. Total, 17 figures with conspicuous pali and, where they can be made out, undissected septa.

the pali are most distinct in two specimens which are otherwise abnormal. the calyces being small, the septa often broken, only five to seven meeting the columella. To make up for this some of them are not cut up into tuberculæ, and bear thin, upright, palial lobes, as many as eight in some calyces (Pl. XVI. fig. 31). In one of these specimens the colony has morbidly hypertrophied columellæ, which project as high as the exsert parts of the septa, and some calyces are filled with a confused mass of septal processes. In another normal and well-grown colony a few septa in some calyces are not cut into trabeculæ, and these are shouldered, as in Dana's type of *Orbicella coronata* (Vaughan, 1918, pl. 28, fig. 4a), but not nearly so conspicuously. The columellæ in this specimen are sometimes compact (Pl. XVI. fig. 31). The fewness and condition of these exceptions show how complete is the degeneration of this species in Tahiti. The peritheca, according to Matthai, is dense in *F. versipora*, though he does not mention its condition in *F. curta* and *F. solidior*. In Tahiti the peritheca is often spongy, especially in colonies in which the calyces are exsert. In some specimens it is so loose that a break does not pass through the calyces as is usual, but between them, as on the right side of the section on Pl. XVII. The perithecal vesicles are made in the usual way by roofing over spaces supported by spines; these horizontal roofs contrast with the sloping dissepiments within the calyces.

3. *FAVIA INGOLFI*, sp. n. (Pl. XVII. fig. 35 and Pl. XX.)

Occurrence.—On the submerged flat of Pa'ea lagoon, growing on the base of a dead colony of *Porites*, in about 4 feet of water. It is very rare, never having been seen in 1925-6 and only once in 1928-30, though the exsert ends of the septa above the projecting and widely-separated calyces make the species conspicuous.

Colour.—Dark umber-brown, uniformly, whether exposed to light or not.

Growth-form.—In rounded cushions, each 6-10 cm. in diameter by about 5 high, covering about a square foot of area. Three of these lumps were detached, of which two were macerated, the third preserved in formol (Pl. XVII. fig. 35).

Relationship.—The species is closely allied to *F. versipora* in its round calyces, which multiply by budding, and the form of the spines on costæ and peritheca. The latter are much larger and very distinctive.

Corallum.—Peritheca vesicular, as in sheltered examples of *F. versipora*, and made in the same way, viz., by roofing over conspicuous spines, as seen in fig. 37 of Pl. XX. Calyces invariably round, thin-walled, 2.5 to 3 mm. in diameter, and from 2 to 4 mm. apart; exsert 1 to 2 mm., usually the latter, depth 2 to 3 mm. to the top of the columella. Septa thin throughout, though the lateral spinules make an appearance of thickening over the walls, but the costæ are so thickened basally that the sides are in contact; they do not extend over the peritheca, which bears small scattered spinules. In a few cases these costal bases fail to join, so that the exsert part of the theca is slit. Principal septa exsert to 1 mm., exsert portions arched, but shape disguised by the large compound spines borne by them and the costæ; these spines are a characteristic feature of the species, reaching their greatest development on the tops or outer angles of the septa; on the principal costæ they are small and horizontally flattened, on the peritheca absent or minute, but well developed where a new perithecal vesicle is being made.

Within the calyces the septa are narrow and vertical, with large granulations on their sides. They and the columella are usually more degenerate than in all but a few specimens of *F. versipora*, major septa often failing to reach

the columella. The trabecular teeth are often strikingly long and slender, and may meet before reaching the columella, and the septum may be dissected to the thecal wall. The columella is made up of few trabeculae, which are, however, thicker than their septal parts. It is sometimes dense, and as thick as half the width of the calyx, though generally a third to a quarter. Pali are completely absent.

Generally the septa simply alternate, the smaller being reduced to lines or ridges of small teeth within the theca, but the corresponding costae may be as broad as the others and bear large spines, or they may be reduced to half the breadth and bear no spines.

In the Tahitian variety of *F. versipora* some few calyces can be found in which three cycles of septa can be clearly distinguished, and in *F. ingolfi* such calyces are frequent. It would be particularly interesting to know whether, in the polyps of such calyces, directive mesenteries are ever developed, but I had, in Tahiti, no means of sectioning the material I preserved. If this should be the case, even exceptionally, the specimens of these two species would show a clear connection between the great genus *Favia* and *Echinopora* and *Leptastrea*. It is clear that, since this cyclic arrangement is found with degeneration in these two species, the loss of regularity characteristic of *Favia* is an evolutionary advance, not a retrogression.

4. *FAVIA COMPLANATA*.

A single specimen from Rihoro Reef, near Papeete, was obtained in 1925, and identified for me by Professor Matthai. It has not been seen in the Pa'ea or Papeari lagoons in 1929-30. Hitherto recorded only from the Red Sea.

5. *FAVIA HEMPRICHII*. (Pl. XXI.)

Closely related to the preceding, but distinct.

In spite of its conspicuousness, only nine specimens were seen in 20 months' search of Pa'ea lagoon: apparently rare everywhere, since this is the first record from the Pacific, and the British Museum possesses only 11 specimens, all collected by Gardiner in his Indian Ocean expeditions; it was previously known from the Red Sea.

In this lagoon it occurs only on the outer submerged flat, on more or less dead *Porites* blocks, on which it practically always occupies a vertical face. It is green in colour, whitish where exposed to full light, deep emerald where shaded, but one specimen was umber-brown with green discs. This green colour remains in the macerated corallum, and may therefore be due to boring algae. The long spines show white the living in colony.

Matthai remarks on the closeness of the relationship of this species to *F. complanata*: "The actual relationship of the two species can be settled only after a comparative study of their polyps." Unfortunately, I am not in a position to make this comparison; yet, in spite of the small size and apparent youth of most of my specimens, the homogeneity of the series and the close agreement in essentials with Matthai's description support the distinction he makes.

Five of my specimens are between 60×45 mm. and 90×80 mm., while the two larger are 160 to 170 mm.×135 mm., and all have the edges *apparently* in active growth. The variations in build described by Matthai, thick-walled and heavy, or thin-walled and light, are well shown by this series; the difference is related to habitat, shaded confined conditions producing the lighter skeletons. At the same time, the walls of even adjacent calyces may vary in thickness

from 1 mm. to 5 or 6 mm., as shown on Pl. XXI. fig. 38, but in the two largest specimens most of the walls are 1 mm. thick, and none exceed 3 mm. Imperfect walls are common, but complete continuity between two to four adjacent thecae is found in only two specimens (Nos. 1 & 3), which are, on the whole, thick-walled, as shown on Pl. XXI. There is also much variation in the lengths of the characteristic, upward pointing, spines; these are usually so delicate that they can hardly reach a museum unbroken, and this may account for the fact that most of my specimens appear more thorny than the illustrations yet published. These spines have triangular bases and granulated points.

In certain particulars my series differs from that of Matthai. The calyces are of the same size, but where the walls are thick their pentagonal shape becomes round or oval; they are shallower, 7 mm. being the maximum depth, 3 to 5 mm. the more usual. The septa, being less well developed, are often vertical, or nearly so, and are fewer, between 15 and 30, averaging 20 instead of 35. The furrowing of the walls between the thecae is rarely seen, and I gather from Matthai's figures that his text is not intended to mean that this is more than occasionally apparent.

In a species which is everywhere rare, and which normally shows reduced building-power (*e. g.*, there are no pali), evidence of special reduction in the Tahitian specimens can hardly be prominent. There is, however, a reduction of the columella which has not been noted in examples from the Red Sea and Indian Ocean. In specimen 1, well developed and thick walled, many columellae are compact interlockings of the septal teeth (which often broaden at their ends to plates as in *Lobophyllia*), while in others the usual clockwise bend of these teeth is so sharp, and the teeth themselves so few, that the centre of the columella is left hollow. In specimen 2 most are compact, but a number of calyces near the thin-growing margin, otherwise complete, have only the rudiment of a columella. No. 3 has hollowed columellae; others are almost absent, or hidden under a thin, morbid, dissepimental growth. In No. 5, the specimen figured, it is excessively loose, sometimes hardly recognizable, as is generally the case over the more normal half of No. 6, which is one of the larger colonies. Over the half of this colony septal teeth have failed to make a columella at all, its place being taken by thin, morbid, horizontal dissepiments like those seen in the local form of *Cyphastrea microphthalma*. Lower down the colony, which grew on a vertical face, these tend to fill the thecae and spread over the walls, nearly filling the spaces between the exsert septa; along its lower edge the colony was dead. Specimen 7 shows every kind of columella, but the imperfect are in the majority, though not many are absent altogether, or replaced by dissepiments.

All but one of the works used in my temporary laboratory at Pa'ea were given to me by their authors, to whom I wish to again express both my thanks and my admiration for their enormous labours and acute intuition. I have criticised freely, but am fully conscious that, as Claparède put it, I owe my further view to climbing on their shoulders.

The photographs, which seem to me exceptionally clear, were taken by my friend Mr. Crake, of Papeete, Tahiti.

LITERATURE

available in Tahiti, used in preparation of this paper.

1899. GARDINER, J. S. On the Astrean Corals collected by the Author in the South Pacific. Proc. Zool. Soc. London, 1899, pp. 734-764, 4 pls.
 1902? GARDINER, J. S. Fauna and Geography of the Maldives and Laccadives.—*Astreidae* and *Fungiidae*, vol. ii. pt. 3, p. 97, and vol. ii. Suppl. i. p. 938.

1906. MARENZELLER, Dr. E. von. Expeditionen S.M.S. 'Pola' in das Rote Meer. XXVI. Riffkorallen. Denks. Math. Natur Kl. der K. Akad. Wissenschaften, Wien.
1907. VAUGHAN, T. WAYLAND. Recent Madreporaria of the Hawaiian Islands and Laysan. Smithsonian Institution, Bulletin 59.
1908. GARDINER, J. S. Percy Sladen Trust Expedition to the Indian Ocean.—Fungiidae. Trans. Linn. Soc. ser. 2, Zool. xiv.
1914. MATTHAI, G. Revision of the Recent Colonial Astracidae possessing distinct Corallites. Percy Sladen Trust Expedition. Trans. Linn. Soc. London, vol. xvii. pt. i.
1918. VAUGHAN, T. WAYLAND. Corals from Murray Island (Australia), Cocos Keeling Island, and Fanning Island. Carnegie Inst. Wash. Papers from Department Marine Biology, vol. ix.
1918. MAYOR, A. G. Ecology of the Murray Island Coral Reef. A- above.
1924. MAYOR, A. G., A Memorial Volume to. Carnegie Inst. Wash. vol. xix., containing, among others, his "Growth-rate of Samoan Corals."
1925. HOFFMEISTER, J. E. Some Corals from American Samoa and the Fiji Islands. Carnegie Inst. Wash. xxii.
1925. BOSCHMA, H. Dr. Mortensen's Pacific Expedition. —Fungiidae. Vidensk. Medd. fra Dansk Naturh. Foren. Bd. 79.
1927. FAUSTINO, LEOPOLDO A. Recent Madreporaria of the Philippine Islands. Bureau of Science, Manila, Monograph 22.
1928. MATTHAI, G. Catalogue of Madreporaria, Brit. Mus. Nat. Hist. vol. vii. A Monograph of the Recent Meandroid Astracidae.
1929. HOFFMEISTER, J. ED. Some Reef Corals from Tahiti. Journ. Wash. Acad. Sci. vol. xix. no. 16.
1929. BOSCHMA, H. The Post-larval Development of the Coral *Mæandra areolata*. Carnegie Inst. Wash., Publ. 391, pp. 129-147.

EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. *Cyphastrea microphthalma*, fig. 2. *Leptastrea* sp. The former $\times 2$, the latter natural size. Infested by the polychæte worm *Phyllochaetopterus* sp., the tubes of which support branches of the corals, upon these the calyces are shallower and more exsert, while the exsertion of the septa, and, in the *Cyphastrea*, the spines, are unusually prominent.

PLATE II.

- Fig. 3. *Herpetolitha limax*. Part of the underside of a "furry" specimen. $\times 2$.
4. *Fungia repanda*. $\times 2$. Showing the edges of the septa dissected into long teeth.

PLATE III.

- Two sections of *Herpetolitha limax*. Fig. 5, a normal specimen; fig. 6, a "furry" specimen, such as that on the preceding plate. Note the perforations, synaptacula, and columellæ.

PLATE IV.

- Fig. 7. *Cyphastrea microphthalma*, Tahitian var. $\times 2$. With narrow septa and no columellæ.
8. An unusually thick specimen of the same, in section. $\times 5$. Showing the absence of columellæ, except for three thin spines in a calyx on the left, narrow and dissected septa, and vesicular peritheca.

PLATE V.

- Fig. 9. *Leptastrea*, specimen No. 13, of the barrier edge series. Form II₁. Thin-walled *ehrenbergiana* form.
10. *Leptastrea facies transversa*, but with definite plates on the tops of the columellæ, and the shouldered septa of *immersa*. No. 7 of the submerged flat, text-fig. 5, on p. 367. $\times 4$.

PLATE VI

- Fig. 11. *Leptastrea*, form VI, L.C. 2 of the inshore series $\times 2$. Honeycomb facies and broken septa, with rudimentary columellæ.

PLATE VII.

- Fig. 12. *Leptastrea*, facies *solida*, inshore series, on basaltic stone. $\times 1$.
 13. Specimen No. 2 of the submerged flat series, central column of text-fig. 4, p. 366. *Porites latistellata* projecting above with three tubes of *Fermetus* sp. $\times 1$.
 14. *L.*, facies *ehrenbergiana*, No. 22, of the barrier edge series. Calyces, forms II. and III. Walls thin. $\times 1$.

PLATE VIII.

- Fig. 15. *Leptastrea*, facies *ehrenbergiana*. $\times 1$. No. 13 of the submerged flat series, with highly distorted calyces.
 16. No. 39 of the barrier edge series. $\times 2$. Calyces and septa of form *rossiana*, but septa shouldered as in form *immersa*; columella of form *ehrenbergiana*.
 17. *L. transversa-immersa*, No. 16, dyke pool. $\times 2$. Septa shouldered, usually a plate on top of columellæ.

PLATE IX.

- Fig. 18. *Lobophyllia* form *corymbosa*. Specimen 2, with tubes of *Phyllochætopterus* sp., both inside and outside the calyces.
 19. *Lobophyllia*, No. 7, from the barrier edge, with deep, open calyces, narrow septa, and thin walls.

PLATE X.

- Fig. 20. *Lobophyllia corymbosa-costata*, specimen 5.2 $\times \frac{1}{2}$. See also text-fig. 8, p. 376.
 21. *L. corymbosa*, to show normal branching. Specimen 13.2. $\times \frac{1}{4}$.

PLATE XI.

- Fig. 22. *Lobophyllia* form *cytherea*. Specimen 17. $\times 1$. Note occasional abnormally large costæ.

PLATE XII.

- Fig. 23. *Lobophyllia corymbosa*, specimen 1, with everted calyces. $\times \frac{2}{3}$.
 24. *L.* form *cytherea*, specimen 13. $\times 1$. A long valley on the top of a triangular plate.

PLATE XIII.

- Fig. 25. *Favia stelligera*. Columns detached from top of the largest specimen. No. 8. Nat. size.
 26. Surface of the top of the same column, showing thin, square-cut septa and rudimentary palial lobes, etc. $\times 5$.

PLATE XIV.

- Fig. 27. Enclosed side of a column from the same specimen, showing hypertrophied columellæ, supported by two or three thin septa, or by none at all. $\times 2$.

PLATE XV.

- Figs. 28 and 29. *Favia curta-solidior*. Two sides of the same, globular, colony. Slightly und nat. size.

PLATE XVI.

- Fig. 30. Sheltered lagoon form of *Favia versipora*, with large shallow calyces. $\times 2$.
 31. An abnormal specimen, having small calyces, few septa, some rudimentary pali, and dense columellæ. $\times 1\frac{1}{2}$.

PLATE XVII.

- Fig. 35. *Favia ingolfi*, sp. n. Nat. size.
 36. *F. versipora*. Section of a normal Tahitian specimen. $\times 2$. Showing dissected septa and loose columella, spongy peritheca, seen especially on the right, where the break has passed through peritheca instead of across the calyces.

PLATE XVIII.

- Figs. 33 and 34. Specimen without columellæ, surface and section. $\times 2$

PLATE XIX.

Fig. 32. *Favia versipora*. $\times 6$. Normal Tahitian form, showing dissection of the septa, loose, sometimes hollow columellae, and the transverse platelets on the costae, which are characteristic of the species.

PLATE XX.

Fig. 37. *Favia ungulifera*, sp. n. $\times 6$. Showing thin dissected septa, small loose columella, and complicated septal and costal spines. The beginning of a roof over costal spines can be seen between *xx*. (perithecal vesicles are made in the same way in *F. versipora*). In some calyces, e. g. the one at the bottom right-hand corner, there is perfect cyclical arrangement of the septa.

PLATE XXI.

Fig. 38. *Favia heinrichi*, specimen No. 5. $\times 2$. Showing full development of spines; walls thick, thin, or broken.

PLATE XXII.

Table of Measurements.

"Notes on the Ecology of the Reef-builders of Tahiti," P.Z.S. 1928, pt. 3, pp. 717-735.

Owing to my leaving England before seeing proofs of this paper, the following corrections are necessary in the

EXPLANATION OF THE PLATES.

PLATE I.

1. Surge following the break of a wave sweeping over the lagoon side of the barrier edge and falling into the lagoon on the right. Off Atine on the west coast. The edge here is high, an erosion flat, and falls abruptly to the lagoon. (N.H. On p. 723, line 28, delete the words "where the edge is low.")
2. Just within the pass at Atine. The reef-edge here is low, and the surface is of *Porolithon* alone, without corals. The water in front of the advancing wave gushes up in fountains through holes left by the *Porolithon* as it grows.

PLATE II.

3. *Acropora pectinata*. A young colony from the sheltered water of the lagoon, showing long branches extending down to the narrow attached base.
4. A colony of the same from outside the reef-edge, exposed to the hammering of the surf. The whole disc is filled in with secondary corallum and enormously thickened.
5. A third colony, from the lagoonward slope of the barrier edge, modified by the sweep of the surge such as is shown on Pl. I. The stalk is not formed, the upper branches only partly developed, and the colony has changed its shape from a bouquet to a paving slab. The slab lay so that the current was from left to right of the photograph. In places the whole of this part of the reef is paved with such flattened-out *Acropora*, always when the reef-edge is low.

PLATE III.

6. *Acropora leptocyathus* from the same habitat, but further modified, so that few branches remain for its identification with the corymbose form of the lagoon. This species is more common than *A. pectinata* in this habitat, and in places the whole of this part of the barrier edge is paved with these flattened-out *Acropora* spp., especially where it is low.

Figs. 7, 8, and 9 illustrate the formation of the Taunoa shore reef described on p. 728.

7. Parasitisation of *Acropora pulchra* by *Montipora* sp., which is growing round and between the branches, killing their lower parts.
8. A portion of the reef-surface turned over, showing that the under part is made of dead branches of *A. pulchra* completely covered with other corals.
9. *Porites (Synarza) convexa* from the reef; a small colony split vertically, exposing branches of *A. pulchra* at its centre. (These are scarcely visible in the reproduction.)

PLATE IV.

Figs. 10-12 *Millepora alcicornis* Hickson.

10. Two specimens from the surf-swept reef-edge. The piece to the left was partially sheltered in a cranny and began to send up plates; that to the right was exposed on the surface, and is an amorphous crust.
11. One of the lagoon, the leafy. In this case the *Millepora* is encrusting dead branches of *Acropora*, except at the ends. Compare the large specimen of Pl. V., which is not so supported. In the present figure note the little plant of *Halimeda* attached to the lower left-hand branch, completely covered by a film of the *Millepora*, an action which has been accomplished before the "roots" of the *Halimeda* had time to rot away. This affords another illustration of the great adaptability of *Millepora* to its surroundings.
12. A second lagoon form, growing in the form of upright plates. This specimen has been partly killed by the accumulation of sand, and the edge is changing to a leafy form.
13. Regeneration of *Acropora cytherea*. The original large colony had fallen, died, and even largely decayed, but in seven places some polyps survived and have grown up into stalked fan-like expansions, miniatures of the original.

PLATE V.

14. *Millepora alcicornis*, the leafy form. One of the five (now six, 1929) principal forms in Tahitian lagoons. Intermediates between all can be found, *e. g.*, fig. 12 on Pl. IV. shows the one with upright plates forming leafy projections under adverse conditions.

This specimen was presented to the Papeete Museum.



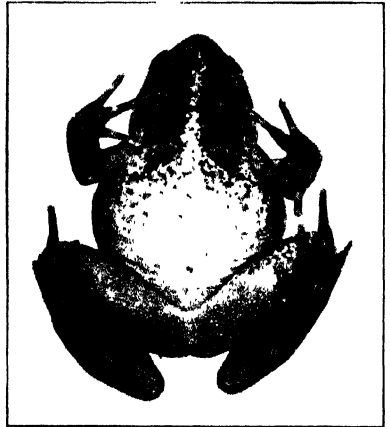
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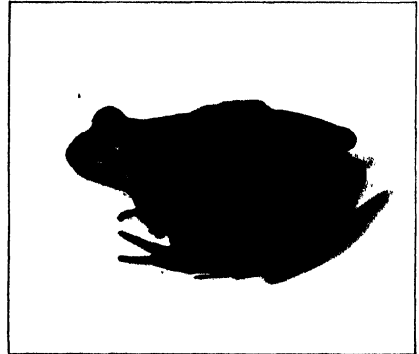
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6.

RANA GRAECA, FROM LIVING SPECIMENS.

18. On the Occurrence of *Rana græca* at Small Altitudes in the Naples District, with some Observations on Habits. By B. W. TUCKER, M.A., F.Z.S., University Demonstrator in Zoology and Comparative Anatomy, Oxford.

[Received December 30, 1930 : Read March 17, 1931.]

(Plate I.)

Rana græca, the brown frog of the Apennines and the mountains of the Balkan Peninsula, was described by Boulenger from Greek specimens in 1891. Its existence in the Italian mountains was subsequently ascertained by Peracca (1897), and its presence has been gradually detected along the whole length of the Apennines. Hitherto it has been usual to regard it as essentially a mountain form. The original specimens from the Korax Mountains were taken at 5800 feet, and larval examples sent to Boulenger from Parnassos came from an altitude of about 3000 feet. Boulenger (1898), quoting information from the late Prof. Giglioli, refers to its occurrence in the Apennines "at altitudes varying between 1300 and 3000 feet," but none of Peracca's material seems to have come from much below 800 metres, or about 2625 feet. Vandoni, in his useful little volume 'Gli Anfibi d'Italia' (1914), also gives 800 metres as the lower limit in the Apennines, stating that it is recorded "su tutta la catena degli Apennini tra 800 e 1000 metri;" and Boulenger, in a more recent work, 'Les Batraciens' (1910), gives the same figures, so that possibly occurrence at the lower levels mentioned by Giglioli has not been confirmed. Ghidini (1901), whose findings are quoted by Vandoni, but whose original paper I have not seen, appears to have established the occurrence of the species in various localities in Canton Ticino not exceeding 350 metres (approximately 1150 feet) in altitude. This is much below the lowest limit ascertained by Peracca, though only a few feet lower than that cited by Giglioli (if the latter is really correct), but in any case would appear to be unusual. The existence of *Rana græca* at much lower levels even than this in the Naples district thus appears worthy of record.

For some years I have been familiar with this frog in the ravines of the hill-country at the base of the Sorrentine Peninsula, which separates the Bay of Naples from the Gulf of Salerno to the southward. I have met with it at four or five places, from about 350 metres below Corpo di Cava to about 180 metres near Cava dei Tirreni, and down to about 100 metres above Amalfi; and I have little doubt that it will be found to occur along the whole stream-system of this area. The animals are typical *Rana græca*, and so far as I can ascertain differ in no respect from material in the British Museum (Natural History) from Siena and the Florence district, with which I have carefully compared them.

As nothing appears to be recorded about the habits of this species, some observations on this subject may be of value. At least in the area under consideration *Rana græca* is essentially a stream frog, apparently agreeing in this respect with *Rana iberica* (cf. Boulenger, 1898, p. 324), and differing from *Rana temporaria* and from *Rana dalmatina* (= *agilis*), the only other brown

frog found in the same region (though not, as far as my observation goes, in the same localities). Throughout the period of its activity, and not only in the breeding-season, it frequents the swift, clear, rocky streams in the wooded ravines on the flanks of the hills, and I have never found it in the daytime so much as even a few yards from water. Along these streams the frogs are quite common, and may usually be found sitting in crevices of the rocks or on boulders in or at the edge of the water, especially near waterfalls, where they are bathed by the spray. When alarmed they dive into the stream, swimming vigorously, and making good headway against the often rather rapid current. As a rule they immediately turn in to the side, seeking when possible to take shelter under the bank or beneath an undercut rock where the water is quieter. This turning reaction is no doubt adaptive and tends to preserve the frogs from being swept downstream by the current, which is often very strong in the early spring. Sometimes on diving into the water they rise to the surface again at once under cover of overhanging rocks or vegetation, but in any case they come up again fairly quickly, and, if not disturbed, soon clamber out. In swimming they use an alternating or paddling action of the hind legs more habitually than *Rana temporaria* or any of the other brown frogs with which I am familiar. According to Boulenger (1898, p. 318), who probably based his statement on information from Peracca, *Rana græca* breeds in the Apennines in March, and this has been quoted by every writer on the subject since; but in the Naples district it apparently does not do so until later. I have been at some pains to settle the normal date, but have been somewhat handicapped by the necessary restriction of my observations to the University vacations.

Well-grown larvæ are found in the late summer. Thus, on August 9, 1924, there were numerous tadpoles, some of them half-metamorphosed, in the stream above Atrani and Amalfi, on the way up to Ravello, while in the third week of August in the following year there were still a moderate number, but the majority had already left the water. As late as September 29, 1929, the Cava stream was still full of tadpoles. They were well advanced in development, but only a few had already metamorphosed. This was somewhat surprising, as only a week later in the previous year there had been no sign of any in the same stream; but it appears probable that spawning was delayed in 1929 by the abnormally cold weather in the early spring. I am indebted to my wife for carrying out some observations in the spring at an earlier date than is possible for me. On March 4, 1929, being then in Naples, she made a special excursion to the Cava stream for this purpose, but found no trace of either tadpoles, spawn, or frogs. I myself examined the stream a month later (April 6) in 1930, with still the same result. In point of fact, the streams in these hills at the beginning of April are rushing torrents, the volume of water and the force of the current being such that frogs or tadpoles would certainly almost all be swept away. My wife examined the Amalfi stream in the third week of March 1929, by which time a few frogs had emerged and a solitary pair were found *in copula*, though no eggs had been laid, nor could any spawn or tadpoles be found in other parts of the stream where the frogs are common later. I visited this stream myself on April 21, 1930. It is less violent than those near Cava, and, although at the date in question there was naturally more water coming down than in autumn, there was not so much that there were no quieter pools where frogs might breed. I still, however, saw only a few *Rana græca*, none of them paired, and no young larvæ or spawn. I did, indeed, succeed in finding three or four single tadpoles of considerable size, but from their stage of development I am confident that they must have been the progeny of late hatchings of the previous year which had managed

to survive the winter without getting washed away, and that they cannot have been hatched that spring, for the possibility of frogs breeding in these streams *earlier* than March is not, I think, to be considered.

It is difficult, therefore, to escape the conclusion that the single pair found in March 1929 were exceptional, and that *Rana graeca* does not normally breed in these streams until late April or May. This conclusion is not only in accordance with the negative observations above mentioned, but is supported by a consideration of the condition of the streams earlier in the spring, which, as already remarked, is such as to make it hard to believe that it would be physically possible for frogs to breed in them even if they attempted to. I hope eventually to be able to settle this matter by direct evidence, but have not thought it desirable to hold up indefinitely the publication of the present paper pending such an opportunity.

It seems somewhat curious that the frogs should breed at these low levels later than at considerable altitudes in the Apennines, and it is difficult to resist the conclusion that fuller evidence is needed as to what is really the normal average breeding date in the mountains.

With regard to the exceptionally low downward extension of the vertical range in the Amalfi district a possible explanation may be suggested: along this coast, in Longfellow's phrase, "the sea and mountains meet," the hills rising almost directly from the shore-line, and, in consequence, the streams in the ravines have essentially the character of mountain torrents down to levels far below that at which typically lowland conditions begin where there is a more gradual transition from the mountains to the plain. It would be interesting to know if the species occurs under similar conditions in other places where the mountains come down to the sea.

In captivity in this country, in an open enclosure with other Anura, *Rana graeca* does quite well, though apt to be a little delicate, especially in the early spring after waking up from hibernation, and developing fatal sores rather readily from any trifling accidental lesion of the skin, particularly of the hind feet. In temperament the species is less stolid than *Rana temporaria*, but much less wild than *Rana dalmatina*. It feeds with equal readiness on insects such as mealworms and on earthworms, showing no such preference for strictly insect food as does, for example, its compatriot *Bufo viridis*.

As good photographs of *Rana graeca*—or, so far as I am aware, photographs of any sort—have not been published, a plate showing several views of living specimens now in my possession is appended to the present account. The figures are taken from healthy and well-acclimatized examples which have wintered in this country. The form and typical mottled coloration, especially the dark mottling on the throat, more or less interrupted in the middle line, which is very characteristic, are well shown. The intensity of the throat mottling is somewhat variable, and even in the same individual may be strongly marked or comparatively faint according to the degree of expansion of the chromatophores at the moment. The general coloration has been sufficiently described by Boulenger, but it may be remarked that a peculiar, pale, almost putty-like tint is rather particularly frequent and characteristic, though darker grey-brown, yellowish brown, and reddish tints are also common.

The dorsal and ventral views were taken through the sides of a narrow glass vessel filled with water. The photographs were taken by Mr. P. A. Trotman, Assistant in this Department, to whom I am much indebted for the time and trouble which he expended on them, the posing and photographing of a living and restless animal like a frog with an ordinary plate camera being no easy matter.

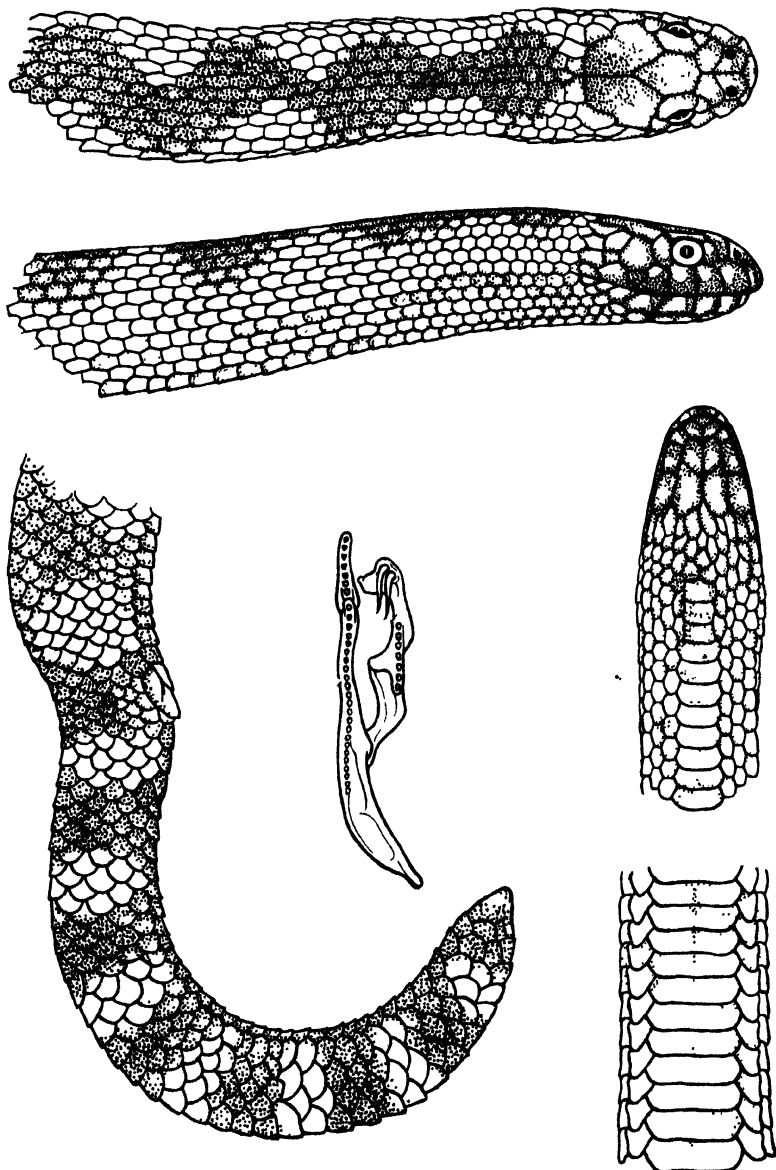
REFERENCES.

- BOULENGER, G. A. (1891.) Description of a new European Frog. *Ann. & Mag. Nat. Hist.* ser. 6, vol. viii. pp. 346-53.
- BOULENGER, G. A. (1898.) The Tailless Batrachians of Europe. Pt. 2, pp. 313-20, Ray Soc., London.
- BOULENGER, G. A. (1910.) 'Les Batraciens,' pp. 250-52. Doin, Paris.
- GHIDINI, A. (1901.) Revisione delle specie di batraci finora incontrati nel Canton Ticino. *Boll. Soc. Ticinese di Sc. Nat.*, Locarno, 1901. (Quoted by Vandoni; original not examined.)
- FERRACCA, M. G. (1897.) Sulla presenza della *Rana græca* Blgr. in Italia. *Boll. Mus. Zool. ed Anat. Comp.* Torino, no. 286, vol. xii. pp. 1-6.
- VANDONI, C. (1914.) 'Gli Anfibi d'Italia,' pp. 42-45. Hoepli, Milan.

EXPLANATION OF THE PLATE.

Photographs of living examples of *Rana græca*.

- Figs. 1 3. Male. 1. Dorsal view. 2. Ventral view. 3. Side view.
4 5. Female. 4. Dorsal view. 5. Ventral view. 6. Side view.



John Bale, Bonn & Darlington, 134 London

EPHALOPHIS GREYI.

19. Description of a new Genus of Sea-snake from the Coast of Australia, with a Note on the Structures providing for complete Closure of the Mouth in Aquatic Snakes. By MALCOLM A. SMITH, M.R.C.S., L.R.C.P., F.Z.S.

[Received December 2, 1930 Read March 3, 1931.]

(Plate I.)

The British Museum has recently received from the north-west coast of Australia two specimens of a Sea-snake of unusual interest. In the formation of the palato-maxillary arch, in scalation, and in general bodily configuration they resemble the genus *Hydrophis*; but they differ from all the known *Hydrophiinae* in having broad ventral shields and in the shape of the rostral shield, in which respect they are like the *Laticaudinae*. The tail also is more rounded and narrower vertically than is usual with Sea-snakes. The broad ventral shields indicate that they are able to progress properly upon land, a power which is not given to any of the *Hydrophiinae*; but in other respects they resemble them too closely to be separated from them, and I propose for them a new genus intermediate between *Hydrophis* and *Hydrelaps*.

EPHALOPHIS, gen. nov.

Maxillary bone not extending forwards beyond the palatine; poison-fangs small, followed after an interval by seven teeth; palatine bone straight. Nostrils superior; nasal shields in contact with one another; head-shields large, regular; body-scales imbricate, in 19 rows at mid-body; ventrals broad, nearly as broad as the body.

EPHALOPHIS GREYI, sp. n.

Holotype, female (Brit. Mus. 1930.11.17.3), collected at Cape Boileau in March 1930 by Mrs. Beatrice Grey, after whom I have pleasure in naming it.

Head moderate; body not slender anteriorly, compressed posteriorly, its greatest diameter being less than twice that of the neck. Diameter of the eye equal to its distance from the mouth. Rostral as broad as high; frontal elongate, longer than its distance from the end of the snout; one pre- and one postocular; one large anterior temporal, followed by two smaller ones; six supralabials, the second in contact with the prefrontal, the third and fourth touching the eye; seven infralabials, the fourth the largest, the first three in contact with the anterior pair of sublinguals; posterior pair of sublinguals well developed, larger than the anterior pair, in contact with one another. 21 scale-rows upon the neck, 19 upon the middle of the body, the scales imbricate throughout and indistinctly keeled. Ventrals 165, three times as broad as the adjacent scales, not tuberculate; preanals considerably enlarged.

Light olive in colour, with 28 dark grey dorsal rhombs upon the body which are more or less confluent vertebrally; tail with 8 dark annuli. Head mottled with dark grey above.

Total length 410; tail 60 mm.

Paratype, male (Brit. Mus. 1931.2.6.2), collected at Willy Creek, near Broome, also by Mrs. Grey. It differs from the type in the following particulars:—Rostral broader than high; two postoculars on the left side; dorsal scales more strongly keeled, many of them multituberculate; ventrals 167.

Total length 440; tail 60 mm.

The elastic ligamentous tissue which connects the anterior extremities of the maxillary bones of snakes has been specially modified in the Sea-snakes to provide for complete closure of the mouth and prevent the entrance of water. In the Land-snakes—using the term in a broad sense for those species that do not habitually frequent water—this strip of tissue is flattened or concave, and the oral margin of the rostral shield is more or less hollowed out, so that an aperture remains for the protrusion of the tongue. In the *Laticaudinae* this aperture is more or less closed by a downward projecting tongue of tissue which lies just behind and is distinct from the rostral shield; it is better developed in *Aipysurus* and *Emydocephalus* than in *Laticauda*. In the *Hydrophiinae*, which are more highly specialized for an aquatic existence than the *Laticaudinae*, this structure has disappeared, and complete closure of the mouth is effected by a downward prolongation of the rostral shield which fits into a corresponding notch in the margin of the dental shield.

In the *Homalopsinae* (Freshwater Snakes) there is a tongue of tissue similar to that which exists in *Laticauda*, but the structure is never well developed in them, and in some it is absent. In *Acrochordus* and *Chersydrus*, two other aquatic Colubrid snakes, complete closure of the mouth is effected by other means. The rostral shield has been excavated until only its upper and outer margins remain, and into the notch thus formed an upward prolongation of the lower jaw fits, the power of closure being increased by the presence of a deep notch on either side of it.

20. A Revision of the Genera and Species of Madagascar Lemuridæ.

By ERNST SCHWARZ*.

[Received October 21, 1930: Read March 3, 1931.]

Very few groups of Mammals have been in so confused a state as the Madagascar Lemurs. Although owing to the work of Mivart †, A. Milne-Edwards ‡, Leche §, and Pocock ¶ their osteology and general anatomy are fairly well known, yet their detailed classification leaves much to be desired. Pioneer work has been done by Forsyth Major ¶ for the *Chirogaleinæ*, by Pocock ** for *Hapalemur*, and by Grandidier and A. Milne-Edwards for the *Indriinæ*. Kaudern's †† recent attempt, based on good and modern material, was not entirely successful, and Elliot's ‡‡ review was a complete failure.

The revision now presented is not final in various respects, owing to incomplete material, although most of the specimens at present available for comparison and almost all of the types, as far as they are still in existence, have been examined. It is hoped, however, that these gaps can be filled in the near future. The author is much indebted for help and information to Mr. M. A. C. Hinton and Miss J. St. Leger of the British Museum, and to Prof. E. Bourdelle and Dr. P. Mathias of Paris.

The differentiation of species and races in Madagascar is primarily determined by the contrast of the moist and well-forested north and east of the island, which is exposed to the trade-winds, and the dry south and west. As a result of the island conditions extreme types, both in external and cranial characters, have been developed, and mutations occur much more frequently than they do elsewhere. The phenomena connected with the process of species differentiation will be discussed in a separate paper.

As regards quotation of literature, a full review is given for the generic names. In the case of the species and subspecies Elliot's 'Review of the Primates' should be consulted; references are given only in special cases which are not or incorrectly quoted by him.

Much difficulty has been experienced in the identification of geographical names on labels, in literature, and on older maps. It is hoped that most of these identifications will prove successful, although I am fully aware that mistakes may have occurred. The orthography, wherever possible, is that of Grandidier's 'Histoire physique, naturelle et politique de Madagascar.' Among the older collections, two are most conspicuous, those of A. Crossley and J. Audebert; both of them have passed through the hands of dealers—Cutter and Gerrard have sold Crossley's, and G. Schneider Audebert's collections. They are now scattered in various museums—London, Tring, Berlin, Leiden,

* Communicated by MARTIN A. C. HINTON, F.Z.S.

† Mivart, P. Z. S. 1864, pp. 611–48; 1867, pp. 247–56, 960–75.

‡ In Grandidier, Hist. Phys. Nat. Polit. Madagascar, vol. iv. (1875), v. (1890), vi. (1875).

§ Festschrift Carl Gegenbaur, pp. 127–166 (1896).

¶ P. Z. S. 1918, pp. 19–53 (1918).

¶ Nov. Zool. i. pp. 2–39, pls. i.–ii. (1894).

** Ann. & Mag. Nat. Hist. (8) xix. pp. 343–52 (1917).

†† Ark. Zool. ix. no. 18, pp. 1–75 (1915).

‡‡ 'Review of the Primates,' i. pp. 87–178 (1913).

Frankfurt, and apparently also in some of the smaller ones. Although many of the original labels have disappeared, I hope I have been successful in identifying a good number of these specimens.

There should be no doubt that all of the Madagascar Lemurs are much more closely related *inter se* than they are to any other group. In spite of the very high degree of specialization developed under insular conditions, they are obviously derived from one common stock that has branched off the common stem since grown into the Indo-African Lorisiformes. I am therefore not in agreement with Mr. Pocock * with regard to the removal of *Daubentonina*, no doubt an offshoot from the Indriid group, from the bulk of Madagascar Lemuriformes. The following arrangement of superspecific groups is proposed here :—

Series LEMURIFORMES.

- A. Carpal and interramal vibrissæ present. Mammæ 1—1 (pectoral) or 2—2 (pectoral and inguinal). 2 permanent incisors. Dental formula
 $I. \begin{smallmatrix} 2.3 \\ 2.3 \end{smallmatrix}, C. \begin{smallmatrix} 1 \\ 1 \end{smallmatrix}, P. \begin{smallmatrix} 2.3.4 \\ 2.3.4 \end{smallmatrix}, M. \begin{smallmatrix} 1.2.3 \\ 1.2.3 \end{smallmatrix}$ LEMURIDÆ.
- a. I² elongated. Bony palate reaching beyond M³, M₃ without hypoconulid.
 Mammæ 1—1 CHEIROGALEINÆ.
 a¹. P² lower than P³ *Microcebus*.
 b¹. P⁴ higher than P³.
 a². P⁴ distinctly caniniform *Phaner*.
 b². P⁴ not distinctly caniniform *Cheirogaleus*.
 b. I² not elongated. Bony palate not reaching beyond M³. M₃ with hypoconulid. Mammæ 1—1 or 2—2 LEMURINÆ.
 c¹. Tail longer than or subequal to head and body. Permanent upper incisors present.
 c². Premaxilla not shortened. P⁴ without metacone. Mammæ 1—1. *Lemur*.
 d¹. Premaxilla shortened. P⁴ with metacone. Mammæ 2—2 *Hapalemur*.
 d¹. Tail shorter than head and body. No permanent upper incisors. Mammæ 1—1 *Lepilemur*.
- B. Carpal and interramal vibrissæ absent. Less than two permanent lower incisors.
 c. Mammæ 1—1 (pectoral). One permanent lower incisor. Front teeth rooted. Dental formula $I. \begin{smallmatrix} 2.3 \\ 3 \end{smallmatrix}, C. \begin{smallmatrix} 1 \\ 1 \end{smallmatrix}, P. \begin{smallmatrix} 2.3.4 \\ 2.3.4 \end{smallmatrix}, M. \begin{smallmatrix} 1.2.3 \\ 1.2.3 \end{smallmatrix}$ INDRIIDÆ.
 e¹. Size large. I² broadened.
 e². Tail short. I⁴ and I³ subequal *Indri*.
 d². Tail medium. I¹ much smaller than I² *Propithecus*.
 f¹. Size medium. Incisor reduced, I² smaller than I³; a broad median diastema *Avahi*.
 d. Mammæ 1—1 (inguinal). No permanent lower incisor †. Front teeth rodent-like, not rooted. Dental formula $I. \begin{smallmatrix} 3 \\ 6 \end{smallmatrix}, C. \begin{smallmatrix} 1 \\ 1 \end{smallmatrix}, P. \begin{smallmatrix} 4 \\ 6 \end{smallmatrix}, M. \begin{smallmatrix} 1.2.3 \\ 1.2.3 \end{smallmatrix}$ [*Daubentonina*].
 DAUBENTONIIDÆ

MICROCEBUS E. Geoffroy.

1828. *Microcebus* E. Geoffroy, Cours Hist. Nat. Mamm., 11e leçon, p. 24.

Type by original designation, *Le Microcèbe roux*=*Microcebus rufus* Wagner.

1835. *Scartes* Swainson, Nat. Hist. Class. Quadr. p. 352.

Type by monotypy, *Scartes murinus* Swainson=*Microcebus murinus murinus* Miller.

1840. *Myscebus* Lesson, Spec. Mamm. pp. 207, 214.

Type by monotypy, *Myscebus palmarum* Lesson=*Microcebus murinus murinus* Miller.

* P. Z. S. 1918, pp. 51, 53.

† A rudimentary *d* 1, present.

1840. *Gliscebus* Lesson, *l. c.* pp. 207, 216.

Type by subsequent designation (here !) *Gliscebus murinus* Lesson
= *Microcebus murinus murinus* Miller.

1841. *Myocebus* Wagner, Arch. Naturg. vii. Bd. 2, p. 19 (err. pro *Myscebus*).

1870. *Mirza* Gray, Cat. Monkeys, Lemurs, etc. B. M. p. 131.

Type by monotypy, *Cheirogalus Coquereli* Grandidier.

1870. *Azema* Gray, *l. c.* p. 132.

Type by monotypy, *Cheirogaleus Smithii* Gray = *Microcebus murinus rufus* Wagner.

1870. *Murilemur* Gray, *l. c.* p. 133.

Type by monotypy, *Microcebus murinus murinus* Miller

Two species.

- | | |
|---|---------------------------------|
| A. Size larger; head and body about 250 mm., tail 280 mm. General colour olive-brown, tail fairly bushy, washed with black. Face-markings indistinct | <i>M. coquereli</i> Grandidier. |
| B. Size smaller; head and body about 130 mm. A very distinct white facial streak from the rhinarium to between the eyes. Tail not bushy and not washed with black | <i>M. murinus</i> J. F. Miller. |

MICROCEBUS MURINUS J. F. Miller.

Two local races.

- | | |
|--|--|
| A. Tail slightly longer than head and body. Colour above grey or reddish grey, below white. Facial streak not accompanied by distinct black marks | [J. F. Miller. <i>M. m. murinus</i> |
| B. Tail not longer or shorter than head and body. Colour above reddish brown, an indistinct dorsal band sometimes present. Facial streak accompanied on both sides by a distinct black stripe which extends as far as but hardly beyond the eyes | <i>M. m. rufus</i> Wager. |

MICROCEBUS MURINUS MURINUS Miller.

Syn. *minima* Boddaert, *prehensilis* Kew, *madagascariensis* E. Geoffroy, *palmarum* Lesson, *myoxinus* Peters, *gliroides* Grandidier, *griseorufus* Kollmann.

The synonymy of this race is fairly complicated, and neither Forsyth Major * nor Elliot † has been successful in disentangling it. Most of the older names can be traced back to three original specimens:

(1) The specimen figured by J. F. Miller ‡. Although there is no description, yet the figure must be taken as a sufficient basis in a technical sense. Major was not justified in rejecting it. The race represented is obviously the greyish southern and western type.

(2) The specimen figured by Buffon § as Rat de Madagascar. This figure was taken from a living specimen in the possession of the Comtesse de Marsan. As the ears are short, this may have been the reddish or eastern race. There is no description of characters.

(3) The animal figured by Brown ||. This was a living specimen in the possession of Mr. Marmaduke Tunstall. Both figure and description are fairly typical of the greyish long-eared western race. There is no reason to doubt this identification as Dr. Forsyth Major did.

* Nov. Zool. i. p. 8 (1894).

† Rev. Primates, i. pp. 98-106 (1913).

‡ 'Various Subjects of Natural History,' pl. xiii. (1777).

§ Hist. Nat. gén. part., Suppl. iii. p. 149, pl. xx. (1776).

|| New Illustr. Zool. pp. 107-08, pl. xlv. (1776).

The following names are based on one or the other of these three specimens :—

Lemur murinus Miller, *l. c.* pl. viii. (1777).

Exclusively based on the specimen figured.

Prosimia minima Boddaert, *Elench. Anim.* p. 66 (1784).

Based on (1) Buffon's *Rat de Madagascar*, (2) Pennant's *Little Maucauco*; this is taken from the 'History,' not from the 'Synopsis'; the quotations are Brown's "*Little Maucauco*," which apparently is the real source, and "Linn. Syst. 44," which is *Lemur murinus* Gmelin, Linnæus, *Syst. Nat.* (13) i. p. 44 (1788), and which is based upon Miller's plate.

As Buffon's animal cannot be identified with certainty, Brown's *Little Maucauco* is taken as the type. This is in accordance with the description, which speaks of a grey animal.

Lemur prehensilis Kerr, Linnæus, *Anim. Kingd.* p. 88 (1792).

Is based on the same sources as *Prosimia minima*, and the same type is here designated for it.

Galago madagascariensis E. Geoffroy, *Ann. Mus. Paris* xix. p. 166 (1812).

Based on the same sources as *minima* and *prehensilis*. The description speaks of a red animal; but as no evidence is available as to another specimen, not too much weight should be attached to it, and the name definitely ranged amongst the synonyms of *murinus*.

Myocebus palmarum Lesson, *Spec. Mamm.* p. 214 (1840).

Gives the description of the grey animal based on a great number of sources taken from literature, amongst which the ones discussed above are contained. It is definitely made a synonym of *L. murinus* Miller.

All the other names are based on various specimens, but not on the ones discussed above.

Lemur pusillus E. Geoffroy, *Bull. Soc. Philom. Paris*, i. p. 90 (1795).

Based on specimens formerly in the Paris Museum and collected by Poivre, Sonnerat, and Commerson. The description is that of the western grey race. Audebert's * plate, which was drawn from one of the original specimens, may be regarded as representing the type.

Cheirogaleus minor E. Geoffroy, *Ann. Mus. Paris*, xix. p. 171, pl. x. fig. 3 (1812).

Named on the evidence of a drawing by Commerson probably taken at Fort Dauphin, S.E. Madagascar †. As the grey race is known to occur in that locality (two specimens in the British Museum, nos. 91.11.30.6-7, coll. Cloisel) *minor* is a synonym of *murinus*. As regards the generic determination of the figure, I think the markings of the face are quite typical.

Microcebus myoxinus Peters, *Naturw. Reise Mossambik, Zool., Säugeth.* i. p. 14, Taf. iii. & iv. figs. 6-9 (1852).

Based on three specimens in the Berlin Museum, of which the one figured is here taken as *lectotype*: no. 319 (mounted skin), 14655 (skull); ♀, St. Augustine's Bay, S.W. Madagascar; collected by Prof. W. Peters.

Specimens examined, 15 :—

Ft. Dauphin, S.E. coast (Brit. Mus.), Bay of St. Augustin (Mus. Berlin—type of *myoxinus*); Ankazoabo, Bara (Brit. Mus.—coll.

* Hist. Nat. Singes, Makis; Makis, p. 19, pl. viii. (1800).

† F. B. de Montessus, *Martyrologe et Biographie de Commerson, Chalon s. Saone, 1889*, pp. 140, 143, 151, 202.

Lamberton); Ambolisatra, north of Tuléar, S.W. coast (Brit. Mus.—coll. Last); Itampolo Bé, north of Tuléar (Mus. Tring—coll. Last); this is probably the material which Forsyth Major * refers to *myoxinus*).

Recorded from Tuléar by Grandidier †, from Morondava by van Dam ‡.

Distribution.—The whole of S.E., E., and W. Madagascar, as far north as the Betsiboka River (Peters—coll. Barnard). Exact limits in central Madagascar not known, but probably only found in the plains. Not extending farther north than Ft. Dauphin on the east coast.

MICROCEBUS MURINUS RUFUS Wagner §.

This name is based on the *Microcèbe roux* of E. Geoffroy || and is clearly applicable to the red eastern race.

Cheirogaleus smithii Gray is also this race. The type is still preserved in the British Museum (no. 37.9.26.78, Madagascar, Verreaux).

Specimens examined, 33 :—

Vohémar, N.E. coast (Mus. Berlin); Mananara, Bay of Antongil (Mus. Tring); Mahambo, north of Foulpointe, N.E. coast (Mus. Tring); E. Imerira (Brit. Mus.); Anabama Forest, Lake Alaotra (Brit. Mus.—coll. Lambertson); Ivohimanitra, Tanala (Brit. Mus.—coll. Major); Vinanitelo, S.E. Betsileo (Brit. Mus.—coll. Major); "S. Madagascar" (probably between Mahanoro and Masindrano) (Brit. Mus.—coll. Crossley); north of Fianarantsoa, Central Betsileo (Brit. Mus.—coll. Shaw).

Distribution.—The whole of eastern, northern, and east-central Madagascar, including the plateau, as far south as Ft. Dauphin. Also the north-west, down to the Bay of Bombétoka.

MICROCEBUS COQUERELI Grandidier.

1867. *Cheirogalus Coquereli* Grandidier, Rev. Mag. Zool. xix. p. 85 (Morondava [S.W. Madagascar]).

Type-locality.—Morondava, S.W. Madagascar.

Specimens examined :—

Morondava (Berlin and British Mus.); also recorded from the neighbourhood of the Bay of Ampasindava, N.W. Madagascar ¶. One living female with young was observed at the London Zoo in November 1929.

This species has the small P² characteristic of *Microcebus*, and is a typical representative of that genus. The long fur and slightly bushy tail are no essential features to warrant a special genus (*Mirza* Gray).

CHEIROGALEUS E. Geoffroy.

1812. *Cheirogaleus* E. Geoffroy, Ann. Mus. Paris, xix. p. 172.

Type by subsequent designation **, *Cheirogaleus major* E. Geoffroy.

* Nov. Zool. i. p. 11 (1894).

† Ann. Sci. Nat. (5) x. p. 378 (1868) (*gliroides*).

‡ Schlegel, Mus. N. H. Pays-Bas, vii. p. 327 (1876) (*myoxinus*).

§ *Microcebus rufus* Wagner, Schreber. Saugth., Suppl. i. p. 291 (footnote) (1840); see also Wagner, l. c. p. 278 (*Microcèbe roux* Geoffr., in synonymy).

|| Cours de l'histoire naturelle des mammifères, 11^e leçon, p. 26 (1828).

¶ Schlegel, Rech. Faune Madagascar, p. 13 (1868) (Kongony River [Ampasindava Bay, N.W. Madagascar]); Jentink, Mus. N. H. Pays-Bas, ix. p. 66 (1887); xi. p. 77 (1892) (Kongony River; Ampasindava; Morondava).

** Elliot, Publ. Field Col. Mus., Zool. viii. p. 548 (1907).

1816. *Chirogaleus* Oken, Lehrb. Naturg. 3. Theil, Zool., 2. Abth. p. xi (emend. Type *Cheirogaleus* E. Geoffroy).
1840. *Cebugale* Lesson, Spec. Mamm. pp. 207, 213.
Type by monotypy, *Cebugale Commersonii* Lesson = *Cheirogaleus major* E. Geoffroy.
1840. *Mioxicebus* Lesson, l. c. pp. 207, 219.
Type by subsequent designation *, *Mioxicebus griseus* Lesson = *Cheirogaleus Milii* E. Geoffroy = *Cheirogaleus major* E. Geoffroy.
1841. *Chirogale* Gloger, Gem. Hand- u. Hilfsbuch Naturg. i. p. 44 (emend e. *Cheirogaleus* E. Geoffroy) †.
1842. *Myspithacus* F. Cuvier (nec Blainville, 1839), Hist. Nat. Mamm., Tabl. gén. method. p. 2.
Type by monotypy, *Le Maki nain* E. Geoffroy ‡ = *Cheirogaleus Milii* E. Geoffroy = *Cheirogaleus major* E. Geoffroy.
1845. *Myoxicebus* Agassiz, Nomenclat. Zool. Add. p. 7 (emend. e *Mioxicebus* Lesson).
1846. *Myoxocebus* Agassiz, Nomenclat. Zool., Index Univ. p. 235 (emend. e *Mioxicebus* Lesson).
1872. *Opolemur* Gray, P. Z. S. p. 853.
Type by monotypy, *Opolemur milii* Gray (nec E. Geoffroy) = *Chirogalus Samati* Grandidier = *Cheirogaleus medius samati* Grandidier.
1913. *Attililemur* Elliot, Rev. Primates, i. p. 111.
Type by original designation, *Cheirogaleus medius* E. Geoffroy.
1928. *Atilemur* Weber, Die Säugetiere (2) ii. p. 736 (err. pro *Attililemur* Elliot).

Three species.

- A. Ears not or slightly tufted. Molars without hypocone. P⁴ more or less molariform, although without metacone. Tail not thinner at base.
- α¹. Size larger. Total length 5-600 mm. P² slightly higher than P³. *Ch. major* E. Geoffroy.
- β¹. Size smaller. Total length about 350 mm. P² distinctly higher than P³. *Ch. medius* E. Geoffroy.
- B. Ears distinctly tufted. Molars with hypocone. P⁴ not molariform. Tail thinner at base. Total length about 300 mm. *Ch. trichotis* Günther.

I am not prepared to accept *Opolemur* as a distinct genus from *Cheirogaleus*. The differences are only gradual, and the essential characters which distinguish the two species *major* and *medius* from *Microcebus* about the same. It would appear to me that the shape of P² is a much more important taxonomic character than the presence or absence of a hypocone or the angular or rounded type of the coronal suture. As a matter of fact this last character varies individually. In one of the two specimens of *Ch. medius samati* from Morondava,

* Elliot, Rev. Primates, i. p. xxx. This designation of the type-species must be accepted, although Elliot's assignation of the generic name to *Hapalemur* is erroneous.

† The form *Cheirogalus* used by Grandidier (Rev. Mag. Zool. (2) xix. p. 85, 1867) in the combination "*Cheirogalus Coquereli*" (= *Microcebus coquereli*) is apparently a *lapsus calami*. The same is true of "*Chirogalus*" *Samati* Grandidier (l. c. (2) xx. p. 49, 1868).

‡ Hist. Nat. Mamm. livr. xxxii. (1821). This specimen is the type of *Cheirogaleus Milii* E. Geoffroy. The quotation by Palmer and Sherborn of "*Myspithacus* F. Cuvier, 1833" is erroneous. The exact title of the book in question is E. Geoffroy, 'Histoire Naturelle des Mammifères', Paris, 1834, which is a reprint of the 'Cours de l'Histoire naturelle des Mammifères' by E. Geoffroy, published in 1828. On page 24 of the 11^e leçon there is, in both editions, no mention of *Myspithacus*, but only the description of *Cheirogaleus Milii*.

W. Madagascar (coll. van Dam) in the Berlin Museum, no. 4353 has the coronal suture of the obtusely angular type described by Major from two specimens in the British Museum from the same source. No. 4354, on the other hand, has the coronal suture broadly rounded like the type which Major supposed to be characteristic of *Cheirogaleus major*, where, however, a similar variation occurs.

It would appear that *Ch. trichotis* is less closely allied to the two other species than they are amongst themselves. The presence of a hypocone in the molars and the elongated P³ are peculiar, but probably of no more than specific importance. The general aspect of the animal is that of a *Cheirogaleus*, and the ear-tufts are only an extreme development of the type present in the young and frequently preserved in the adult of *Ch. major crossleyi*.

The detailed classification of this genus is the weak point of this paper, and, owing to insufficient material, open to revision.

CHEIROGALEUS MEDIUS E. Geoffroy.

Two local races.

- A. Size larger *Ch. m. medius* E. Geoffroy.
B. Size smaller *Ch. m. samati* Grandidier.

CHEIROGALEUS MEDIUS MEDIUS E. Geoffroy.

Syn. *thomasi* Major.

Type-locality.—Ft. Dauphin, S.E. Madagascar (also of *thomasi*).

Specimens examined, 3, all from the type-locality (Brit. Mus.—coll. Cloisel).

The material examined of this eastern race is the same as that studied by Forsyth Major. The drawing by Commerson's artist, published by E. Geoffroy in the original description of *Cheirogaleus medius*, appears to be quite typical of this species, showing the broad nasal streak which is widened in front near the muzzle. Major's name is an absolute synonym of *medius*. Nothing is known of the distribution of *Opolemur* north of Ft. Dauphin in eastern Madagascar.

CHEIROGALEUS MEDIUS SAMATI Grandidier.

Type-locality.—Tsidsobon River, W. Madagascar.

Specimens examined, 4 (2 at Berlin and 2 in London, all collected by van Dam at Morondava, W. Madagascar). They are all of the smaller type as described by Major. The specimens in the British Museum are those on which the genus has been founded*. Whether the characters upon which the eastern and western specimens are separated by Forsyth Major are really constant remains to be examined. This question cannot be definitely decided with the material at hand.

CHEIROGALEUS MAJOR E. Geoffroy.

It would appear that two local races of this species, an eastern and a western, can be distinguished. The material at hand is, however, not sufficient to make this certain. The following key is therefore only provisional :—

- A. Ears hairy inside and out, with hardly a naked tip. Colour strongly washed with brownish on fore parts [Grandidier.
Ch. m. crossleyi
B. Ears naked for their distal half. Colour rather more greyish *Ch. m. major* E. Geoffroy.

* Major, Nov. Zool. i. p. 18 (1894) ; Pocock, Ann. & Mag. Nat. Hist. (8) xix. p. 344 (1917).

CHEIROGALEUS MAJOR MAJOR E. Geoffroy.

Syn. *commersonii* Wolf, *milii* E. Geoffroy, *typicus* A. Smith, *typus* F. Cuvier, *griseus* Lesson, *adipicaudatus* Grandidier.

Cheirogaleus major E. Geoffroy and *Lemur Commersonii* Wolf * are based upon Commerson's well-known drawing, published by E. Geoffroy.

Type-locality.—Fort Dauphin, S.E. Madagascar.

Cheirogaleus Milii E. Geoffroy is based on a specimen brought home alive from Madagascar by Commandant Milius and figured by E. Geoffroy † as *Lemur murinus*; this specimen is also the type of *Mioxicebus griseus* Lesson and the original of *Myspithacus* F. Cuvier.

Chirogaleus adipicaudatus Grandidier is based on the western race and provisionally regarded as a synonym of *Ch. m. major* E. Geoffroy. The type of *Cheirogaleus typicus* A. Smith is in the British Museum (no. 37.9.26.77, ♂ imm., "Madagascar," Verreaux). From the shape of the ears and the pale colour it is more like the western than the northern race. As the western race apparently occurs as far as Fort Dauphin on the south-east coast, *typicus* will probably turn out to be a synonym of *Ch. m. major* E. Geoffroy.

CHEIROGALEUS MAJOR CROSSLEYI Grandidier.

Syn. *melanotis* Major, *sibreei* Major.

Chirogaleus crossleyi Grandidier, the type of which I have not seen, is apparently a half-sized specimen with the tail broken. The description of skin characters and colours closely agrees with a skin in the Berlin Museum from the type-locality, obtained from K. Fritsche. This is an animal with small, slightly hairy, darkish ears, brownish grey above, with a golden throat, creamy underside, and the normal size of a *Cheirogaleus major*.

CHEIROGALEUS TRICHOTIS Günther.

Type-locality.—Not known. Only known from the type-specimen (Brit. Mus. no. 75.1.29.2; ♂; coll. Crossley).

PHANER Gray.

1870. *Phaner* Gray, Cat. Monkeys, Lemurs, etc. B. M. p. 131.

Type by monotypy, *Phaner furcifer* Gray = *Lemur furcifer* Blainville.

The combination of Microcebinae and Cheirogaleine characters, together with the development of special features, amply justifies the retention of a separate genus for this species. The rounded brain-case, the development of a hypocone in the molars, and the shape of P⁴, which is not molariform, are as in *Microcebus*. The rounded posterior margin of the frontals is much as in *Cheirogaleus*, as is also the bushy tail. The extremely elongated anterior premolar in both jaws may be regarded as derived from the condition found in *Cheirogaleus*, and is paralleled by the development in the Galago *Euoticus elegantulus* Le Conte. The upper I² and lower incisors are more elongated and slanting than in any other Lemur. Of skin characters the development of a distinct spinal line must also be regarded as a feature which separates this genus both from *Microcebus* and *Cheirogaleus*.

One species.

* Johann Wolf, Abb. u. Beschr. merkw. naturg. Gegenst. (1st ed.) ii. p. 9, Taf. iv. (1822).

† Hist. Nat. Mamm. livr. xxxii. (1821).

PHANER FURCIFER Blainville.

Type-locality.—Probably the region of the Bay of Antongil, N.E. Madagascar; the type in the Paris Museum was collected by Goudot, and was sent to Paris in 1834. There is no definite record of the occurrence of this species considerably south of the Bay of Antongil, all of Pollen and van Dam's specimens being from the north and north-west of Madagascar, and the only one of Crossley's with a definite locality in the Berlin Museum (no. 3838) from Vohémar, N.E. coast.

Specimens examined, about 10; the following with definite localities:—

Vohémar, N.E. coast (Mus. Berlin—coll. Crossley); Andoany ("Maroandiana"), N.W. coast (Berlin Mus.—coll. Pollen and van Dam). A couple has been kept alive at the Berlin Zoo in 1908 and 1909, and is now in the Berlin Museum.

This species has been recorded by Pollen and van Dam from various localities on the N.W. coast, north of the Bay of Bombétoka (Bay of Ampasindava, Jangoa River, Kongony River), but also farther south at Morondava, on the W. coast. Found by M. J. Audebert at "Passumbé," N.E. coast.

In the material at hand a white tail may or may not be present.

HAPALEMUR I. Geoffroy, 1851.

1851. *Hapalemur* I. Geoffroy, l'Institut, xix. p. 351.

Type by monotypy, *Hapalemur griseus* E. Geoffroy.

1870. *Prolémur* Gray, P. Z. S. p. 828, figs. 1-4.

Type by monotypy, *Hapalemur simus* Gray.

1855. *Hapalotemur* Giebel, Die Säugethiere, p. 1018 (emend. e *Hapalemur* I. Geoffroy).

Two species.

- | | |
|--|------------------------------------|
| <p>A. Size large. Total length 900 mm.; basal length of skull 67-69 mm. No wrist-gland. An ochraceous pygal patch always present. A diastema behind canine; P³ not molariform; all molars with hypocone; M¹ also with protostyle</p> | <p>... <i>H. simus</i> Gray.</p> |
| <p>B. Size medium. Total length 710 mm.; basal length of skull 51-55 mm. A wrist-gland present. No pygal patch. No diastema behind canine; P¹ molariform. Molars with cingulum, but without accessory cusps.</p> | <p>... <i>H. griseus</i> Link.</p> |

HAPALEMUR SIMUS Gray.

The type of this species was kept alive at the London Zoo and is without definite locality. This species has also been exhibited at the Berlin Zoo. Apart from its superior size and the absence of wrist-glands, it is easily distinguishable from *H. griseus griseus*, which it resembles in colour, by the presence of a pale rusty pygal patch. The general and skull-characters which characterize this species have been fully and most carefully described by Pocock*. The shape and position of the malar foramen used as important characters are, however, variable in both *H. simus* and *griseus*. I am not prepared to accept Pocock's division of this genus into two, *Prolémur* and *Hapalemur*. The differences used by him appear to me to be of no more than specific value.

Specimens examined, 4, including the type (Brit. Mus. no. 70.9.2.2); only one with definite locality (Brit. Mus. no. 84.10.20.4; Nandihizana, Central Betsileo, S.E. Madagascar, J. Waters coll.). A second specimen with a locality record is in the Leiden Museum (coll. by M. J. Audebert, "Passumbé," N.E. coast).

It would appear, therefore, that the distribution of *H. simus* includes the whole forested region of eastern Madagascar. It has not been recorded up to now from the north-west.

HAPALEMUR GRISEUS Link *.

Two local races.

- A. General colour greyish green *H. g. griseus* Link.
 B. General colour reddish green *H. g. olivaceus* J. Geoffroy.

HAPALEMUR GRISEUS GRISEUS Link.

Syn. *cinereus* Desmarest †, *schlegeli* Pocock ‡.

Specimens examined, 7, from the following localities :—

Lake Alaotra, Central N.E. Madagascar (4, Brit. Mus.); Ambatondrazaka Antsihanaka, S. of Lake Alaotra (1 skull, kindly lent by Herr Flemming of Hamburg); District Ambalavao, S.E. Madagascar (Brit. Mus.). Tany Malandi, N.W. coast (1, Berlin Mus.—coll. Pollen and van Dam).

The specimens collected by Pollen and van Dam at Ambazoana, in the neighbourhood of the Bay of Ampasindava, N. W. Madagascar §, and referred to *schlegeli* by Pocock, are clearly *griseus*, as is proved by the specimen now in the Berlin Museum.

The type of *Hapalemur schlegeli* Pocock (Brit. Mus. no. 17.3.27.2) is a skull originally in the collection of the Zoological Society of London without definite history and obviously from a captive specimen. The small size is probably due to confinement. As Pollen and van Dam's specimens have turned out to be true *griseus*, there seems to be no reason to keep *schlegeli* as a distinct race, the more so as, in a general way, the distribution of the two races of *H. griseus* can be given. The range of *H. g. griseus* would appear to be co-extensive with that of *Lemur fulvus rufus*, e. g., the whole south and west, and the dry central plateau as far east as Lake Alaotra; it also goes north beyond the Betsiboka River in the north-west, just as *L. f. rufus* crops up there among the population of *L. f. albifrons*. *H. g. olivaceus*, on the other hand, is found in the moist and wooded north-east and east, probably as far south as Fort Dauphin, its range thus covering that of *L. f. albifrons*, *fulvus*, and *collaris*.

HAPALEMUR GRISEUS OLIVACEUS I. Geoffroy.

The type of this race is still in the Paris Museum. There is no type-locality. Specimens examined, 19, from the following localities :—

Mananare, Bay of Antongil (Mus. Tring); Vohémar, N.E. coast (Brit. Mus. and Mus. Berlin); Tamatave, E. coast (Mus. Berlin—coll. A. Voeltzkow); Analamazaotra, between Tananarive and Andovoranto, E. Madagascar (Brit. Mus.—coll. Dr. Meller); Ambohimitombo, Tanala country, E. Madagascar (Brit. Mus.—coll. Forsyth

* 1795. *L[emur] griseus* Link, Beytr. Naturg. i. 2 Stück, p. 65 (ex *Le Petit Maki Gris* Buffon, Hist. Nat., Suppl. vii. p. 121, pl xxxiv., 1789). This specimen, collected by Sonnerat, is still in the Paris Museum (Gallery no. 119), and is the original of Audebert's plate and of *Lemur cinereus* Desmarest. E. Geoffroy's name was published one year later than Link's description.

† 1820. *Lemur cinereus* Desmarest. Mammalogie, i. p. 101 (err. pro *griseus* E. Geoffroy).

‡ 1917. *Hapalemur schlegeli* Pocock, Ann. & Mag. Nat. Hist. (8) xix. p. 350 (no type-locality).

§ Schlegel, Mus. H. N. Pays-Bas, vii. p. 317 (1876), Ampasindava ("Passandava"), Bay of Kakamba ("Kakambe"); Jangoa River ("Seangoi"); Tany Malandi; Anorosontsanga ("Mourountsang").

Major); Vinanitelo, S. Betsileo (Brit. Mus.—coll. Forsyth Major). Also 9 specimens without history, including the type of *Hapalemur schlegeli* Pocock (Brit. Mus. no. 17.3.27.2).

Of the localities recorded by Schlegel and Jentink for the specimens in the Leiden Museum, those referring to the specimens collected by M. J. Audebert, all on the N.E. coast, should be included under this race (Mananara, Bay of Antongil; Mahambo, near Foulpointe, "Maisine" (?=Fénerive), Maleno, all on the east coast north of Tamatave).

LEMUR Linnæus.

1758. *Lemur* Linnæus, Syst. Nat. (1) i. p. 29.

Type by subsequent designation (Thomas, P. Z. S. 1911, p. 129),
Lemur catta Linnæus.

1762. *Prosimia* Brisson, Règn. Anim. (2) p. 13.

Type by subsequent designation (Elliot, Rev. Primates, i. p. xxviii 1913), *Lemur catta* Linnæus.

1780. *Procebus* Storr, Prodr. Method. Mamm. p. 32, Tab. Spec. A.

Type by original designation, *Lemur catta* Linnæus.

1806. *Catta* Link, Beschr. Naturalien-Sammlung Univ. Rostock, i. p. 7.

Type by tautonymy, *Lemur catta* Linnæus.

1819. *Maki* Muirhead, Brewster's Edinburgh Encyclop. xiii. p. 405.

Type by subsequent designation (here), *Maki mococo* Muirhead=
Lemur catta Linnæus.

1863. *Varecia* Gray, P. Z. S. p. 135.

Type by subsequent designation (Elliot, l. c. p. xxx, 1913),
Lemur variegatus Kerr.

1878. *Mococo* Trouessart, Rev. Mag. Zool. (3) vi. p. 163.

Type by monotypy, *Prosimia catta* Lesson *=*Lemur catta*
Linnæus.

1895. *Eulemur* Haeckel, Phylogenie Wirbelth. iii. p. 600 (*nom. nud.*).

Six species.

- | | |
|---|--|
| A. Scrotum naked; a wrist-gland and a horny spur on forearm. No presphenoid nor palatinal sinuses. Molars with hypocone. Malar foramen large. Tail ringed black and white | <i>L. catta</i> Linnæus. |
| B. Scrotum hairy; no wrist- nor arm-glands. Tail not ringed in adult. | |
| a. Molars without hypocone and protostyle. No presphenoid nor palatinal sinuses. Malar foramen large. Colour variegated, black and white, or black, red, and white | <i>L. variegatus</i> Kerr. |
| b. Molars with hypocone and protostyle. Colour uniform. | |
| a ¹ . Cheek-fringe and ear-tufts present. Presphenoid inflated, leaving only a small flat area near the sphenoid suture. Sexes different in ground-colour, the male being black, the female brown or reddish | <i>L. macaco</i> Linnæus. |
| b ¹ . No cheek-fringe nor ear-tufts present. Sexes more or less alike in ground-colour. | |
| a ² . Ears concealed in fur, hairy inside and out. Both palatinum and presphenoid hollowed out; palatinal sinus projecting into orbit | [I. Geoffroy. <i>L. rubriventer</i> |
| b ² . Ears not concealed in fur, naked inside. No presphenoidal sinus. | |
| a ³ . Sides of muzzle white or whitish; palatinal sinus present or absent | <i>L. mongoz</i> Linnæus. |
| b ³ . Sides of muzzle (generally) black; palatinum inflated, but not projecting into orbit | <i>L. fulvus</i> E. Geoffroy. |

* *Les mococos* Lesson, Spec. Mamm. p. 222 (1840).

LEMUR CATTÀ Linnæus.Syn. *mococo* Muirhead †.

No type-locality. Based on a specimen brought alive from Madagascar in 1748 by Capt. Isaac Worth, and figured by Edwards, Nat. Hist. Birds, iv. p. 197, pl. cxcvii. (1751). Except a great number of living and museum specimens without locality, only four specimens from Tuléar, S.W. coast, have been examined (Mus. Berlin). This species, which inhabits rocky open country, is found in south-western, southern, and south-eastern Madagascar. It has been found by van Dam ‡ at Morondava, Matseroke, and the Bay of St. Augustin in the south west, and is recorded by him as far north-east as the region of Ft. Dauphin. It has also been observed by Shaw § in the open country in southern and south-eastern Betsileo.

LEMUR FULVUS E. Geoffroy.

5 local races.

A. Forehead in males rusty red.

a¹. Supraorbital marks conspicuous, white. Male grey, female reddish. *L. f. rufus* Audebert.

B. Forehead in males not rusty red.

a². Head black, at least in males.

[(dark phase).]

a³. Cheeks whitish. Ground-colour mummy-brown *L. f. albifrons* E. Geoffroyb³. Cheeks yellowish white or dirty yellowish. Ground-colour olive-brown *L. f. fulvus* E. Geoffroy.c³. Cheeks orange-yellow. Ground-colour light brown; a faint spinal line generally present. Female generally with the head grey *L. f. collaris* E. Geoffroy.b². Head in males white; females with grey head and deep rufous body-colour *L. f. albifrons* E. Geoffroy**LEMUR FULVUS ALBIFRONS** E. Geoffroy.Syn. *Frederici* Lesson, *nigerrimus* Sclater.

Neither the type of *albifrons* nor *Frederici* || is preserved in the Paris Museum, nor is any type-locality known.

Of this race there are two mutations which occur together, viz., (1) a normally black-headed, whitish-cheeked type, with dark ground-colour, in which the female is only slightly paler than the male, and (2) the "*albifrons*" type, which shows a reduction of black pigment, the ground-colour being more reddish, especially so in the female; the male has the whole crown, cheeks, and beard white or whitish, but there are females which show a whitening on the head, although the normal phase of the "*albifrons*" female has a lead-grey head and a grey muzzle. Both the male and female coloration of the "*albifrons*" phase were already known to E. Geoffroy St. Hilaire and are figured in the 'Histoire naturelle des Mammifères.' But it appears to have escaped notice that a dark mutation exists which is the normal type. Specimens of both types have been examined from Vohémar, Mananara, Androutsé.

Specimens examined, from the following localities (the light phase is marked *, the dark phase **):—

Vohémar, N.E. coast * ** (Brit. Mus., Mus. Berlin); Sahambavany, N.E. coast * (Mus. Berlin); Mananare * ** (Mus. Berlin, Mus. Tring);

† 1819. *Maki mococo* Muirhead, Edinburgh Encyclop. xii. p. 405 (e *Maki mococo* (*lemur cattà*) Desmarest, Nouv. Dict. Hist. Nat. (2nd ed.) xvii. p. 437 (1817).

‡ Schlegel, Mus. H. N. Pays-Bas, vii. p. 314 (1876).

§ P. Z. S. 1879, p. 132.

|| Based on E. Geoffroy's plate of the male, *Maki à front blanc* (Hist. Nat. Mamm. livr. iii, 1819).

Maroansetra * (Mus. Berlin); Androutsé *** (Mus. Paris); Ampazénardo * (Mus. Paris); "Bay of Antongil" *** (Mus. Paris) (all the last-named localities in the vicinity of the Bay of Antongil).

The range of this local race apparently includes the north-eastern coast of Madagascar as far as, and slightly beyond, the Bay of Antongil. The northern and western limit is uncertain; only the dark phase apparently occurs on the north-west coast (see under *rufus*).

Both the white-headed and black-headed phase are at present exhibited alive at the Berlin Zoo.

The type of *Lemur nigerrimus* Sclater is now mounted in the Paris Museum (no. 1882-2753; Gallery no. 104 A, ♂); there is also a similar female specimen and a third skin in the Berlin Museum (A. 5181, ♂, Zool. Gardens, Berlin). All of these are melanistic specimens of some race of *L. fulvus*. The thick fur of the type would suggest its being a melano of *L. f. albifrons*. It is now definitely placed in its synonymy.

LEMUR FULVUS FULVUS E. Geoffroy.

Syn. *macromongoz* Lesson, *bruneus* van der Hoeven.

Lemur fulvus E. Geoffroy is based on two specimens, both of which were alive and without history, and both of which have not been preserved at the Paris Museum. Apparently they both represent the same race, viz., the one which lives in the Tamatave region. The two original specimens have been described and figured by Buffon and E. Geoffroy St. Hilaire respectively.

(1) *Le Grand Mongous* Buffon, Hist. Nat., Suppl. vii. pp. 118-19, pl. xxxiii.

(2) *Maki brun* (*Lemur fulvus*) E. Geoffroy, Ménagerie du Muséum National, article "*Le Maki Mococo et le Maki brun*," with coloured plate of what is apparently a female animal. This is the specimen mentioned in the original description of *fulvus*. It has been examined by E. Geoffroy himself, and is regarded as the type of the species.

Prosimia macromongoz Lesson † is based on various sources, among which are E. Geoffroy and Buffon. The description is that of *Lemur fulvus*, the name apparently derived from the "Grand Mongous" of Buffon. This name is now definitely placed in the synonymy of *L. f. fulvus*.

Lemur bruneus van der Hoeven (often quoted *brunneus*) is only a new name for *fulvus*, being based on the same original sources.

Specimens examined, 29, from the following localities:—

No locality, mostly from captivity, 19 (also a great number of living specimens in various Zoological Gardens); Andragoloaka, S.E. of Tananarive, Prov. Imerina (Mus. Berlin—coll. Crossley); Lakato Forest, Ankay, N.E. of Tananarive, Imerina (Brit. Mus.); Sakana, opposite the Ile St. Marie (Mus. Berlin—coll. Voeltzkow); Ambotorao, opposite the Ile Ste. Marie, N.E. coast (Brit. Mus.); Tamatave (1 specimen kindly lent by Herr Flemming of Hamburg).

The range of this race is not completely known. It obviously inhabits the coast between the Bay of Antongil and Andovoranto, but may go farther south, as far as Mahanoro. In the interior it appears to go into the forest-belt east of Tananarive, but is replaced on the plateau by a mixed population of black and red-fronted types later on discussed under *L. f. rufus*.

† Spec. Mamm. p. 226 (1840); enumerated under *L. mongoz* by Elliot (Rev. Primates, i. p. 134, 1913).

The specimen, listed under *Lemur fulvus albifrons* by Kaudern *, from Sahabevava, east coast, opposite the Ile Ste. Marie, is this race.

This race is about the most common Lemur in captivity. It is generally mislabelled "*L. mongoz*, *nigrifrons*, or *brunneus*."

LEMUR FULVUS COLLARIS E. Geoffroy.

Syn. *melanocephalus* Gray, *xanthomystax* Gray, ? *flavifrons* Gray, *cinereiceps* Grandidier and Milne-Edwards.

The type of *Lemur collaris* cannot be made out with certainty. It may be a specimen in the Paris Museum (Gallery, no. 73, ♂, "mort à la Ménagerie, mars 1819"). This specimen, which is probably the original of E. Geoffroy's plate of *Le Mongous* †, was originally labelled *Lemur collaris*, which was changed later on into "*Lemur mongoz* (L.) var." As *L. collaris* was described in 1812, and the specimen died in 1819, it may well have been the type. The skin is faded, but clearly the south-eastern race.

The type of *Lemur melanocephalus* Gray is in the British Museum (no. 55.12.24.55, ♀, Zoological Society; skin, no skull). This is a dark, black-headed specimen of the south-eastern race. The face is extremely black, without any pale marks. The bright cheeks and the general colour of the back, although strongly suffused with black, leave no doubt about its position.

The type of *Lemur xanthomystax* Gray (British Museum, no. 44.5.14.24, ♂ subad., "Madagascar," bought from Parzudaki, skin and skull). This is much like the supposed type in Paris. An exactly similar specimen is in the British Museum (no. 50.8.29.13).

Although Elliot asserts that no type of *Lemur cinereiceps* Grandidier exists, I have no doubt that two specimens in the Paris Museum are the originals of Grandidier's plate. Both are mounted skins, with the skulls inside, somewhat faded from exhibition, and both females. They fit fairly closely E. Geoffroy's plate of the female "*Mongous*" ‡, but have a grey head without black markings. From the same localities there are typical specimens of *L. f. collaris* in the Paris Museum. To avoid further confusion a type is now selected.

Paris Museum no. (Cat. Gén. 1882-1515, Gallery, no. 98 C; ♀, Farafangana, S.E. Madagascar; Lantz coll.; lectotype). The second specimen is taken as paratype (Cat. Gén. no. 1882-1514, Gallery, no. 79 D; ♀ (labelled ♂), Salohy, north of Farafangana; coll. Lantz).

Specimens examined, 16; from the following localities (all on the S.E. coast):—

Salohy (Mus. Paris); Farafangana, about 23° S. (Mus. Paris); Loholoka, about 21° 60' S. (Mus. Paris); Ft. Dauphin, about 25° S. (Brit. Mus.).

Also 9 specimens without locality, all from Zoological Gardens, including the types of *collaris* (?), *melanocephalus*, *flavifrons*, and *xanthomystax*, and a living pair at the Frankfurt Zoo.

The range of this form is only imperfectly known. It clearly inhabits the south-eastern coast from Ft. Dauphin in the south to at least Masindrano in the north. How far it goes into the interior is not known, but it would appear that it is restricted to the coastal forests, as *L. f. rufus* is already found in eastern Betsileo. It also remains to be ascertained where the ranges of *collaris* and *fulvus* meet.

This race, which may be slightly smaller than the other races, although this is not quite proved, is characterized by the bright cheeks and brownish

* Ark. Zool. ix, no. 45, Taf. ii, fig. 1 (1915).

† Hist. Nat. Mamm. livr. ii. (Jan. 1819).

‡ Hist. Nat. Mamm. livr. ii. (1819).

back. There is considerable individual variation, especially as regards the amount of black, grey, or reddish brown on the crown and forehead. There are female specimens which have a lot of black on the head like the males, but specimens occur too without any black markings, or even with a reddish crown, which resembles the colour of the back. I believe the type of *flavifrons* Gray (Brit. Mus. no. 67.10.5.19, ♀ subad., Zoological Society; bad skin and skull) and an exactly similar specimen (Brit. Mus. no. 76.1.31.26, ♀ old) represent this extreme colour phase.

LEMUR FULVUS RUFUS Audebert *.

Syn. *rufifrons* Bennett.

The type-specimen of *Lemur rufus*, which has been figured by Audebert, is still in the Paris Museum, although in a rather bad condition, but easily identifiable as regards its characteristic features. It is mounted with the skull inside: "Paris Museum no. (old catalogue) 73, (Gallery Cat.) 74, ♀; no history." It is a typical female of the race usually named *rufifrons*, with very white supraorbital marks and hardly any grey on the crown. A specimen from Betsako, Bay of Bombétoka, north bank, is exactly like it (Brit. Mus. 91.122.5, old ♀; G. T. Last coll.).

The type of *Lemur rufifrons* Bennett (Brit. Mus. no. 55.12.24.54, old ♂, Zoological Society; skin and skull) is a specimen from captivity and without definite history.

Specimens examined, 36, from the following localities:—

No locality (including types of *rufus* and *rufifrons*) 10 (Brit. Mus.; Mus. Berlin; Mus. Paris); localities in E. Betsileo, S.E. Madagascar: Ankona Forest (Brit. Mus.—coll. Cowan); Ambohimanga, N.E. of Fianarantsoa (Brit. Mus.); "S. Centr. Madagascar," probably E. or C. Betsileo (Mus. Berlin—coll. Hildebrandt), Fianarantsoa; Kazaoka, Upper Manakara River, west of Farafangana, S.E. coast † (Mus. Berlin—coll. J. Audebert); Tuléar, S.W. coast (Mus. Berlin); Morondava, W. coast (Mus. Paris—coll. Grandidier); Kandani, Bay of Bombétoka, S. bank (Mus. Berlin; Mus. Frankfurt—coll. Voeltzkow); Betsako, Bay of Bombétoka, N. bank (Brit. Mus.—coll. Last); Narendry Bay, N.E. coast (Mus. Berlin); Ambatondrazaka, S. of Lake Alaotra, Prov. Antsihanaka (kindly lent by Herr Flemming, Hamburg; coll. Tramond).

The range of *L. f. rufus* includes the greater part of Madagascar, all the central plateau, and the west coast. It has been maintained by Lorenz ‡ that it does not occur north of the Bay of Bombétoka, but the specimens from Betsako and Narendry Bay are undeniable proof of its crossing the Betsiboka River. It would appear that, except the north and a fairly narrow strip on the east coast, the whole mainland of Madagascar is inhabited by this race.

As a matter of fact the majority of the individuals found north of the Betsiboka River are black-headed and much like the black-headed phase of *L. f. a. rufus*; but there can be no doubt that a mixed population is found in a considerable part of the north. At present I am not prepared to say definitely whether this is due to mutation or, what is more probable, to secondary invasion of the northern area by *L. f. rufus* down the right bank of the Betsiboka River. Unfronted skins have been recorded from north of the River Betsiboka

* 18. *Lemur rufus* Audebert, Hist. Nat. Singes, Makis; Makis, p. 12, pl. ii. (no locality).
 † I have been able to find this place on a map, but according to Audebert's 1880 itinerary it is in this region.
 ‡ Ges. xxi. p. 448 (1898) ("*Lemur mongos rufifrons*").

from Betsako (Last), Narendry Bay (probably Crossley—Mus. Berlin), Anorontsanga (Pollen and van Dam); also a specimen lent by Herr Flemming from Ambatondrazaka, south of Lake Alaotra. Black-headed skins have been recorded from the same general region, but not south of the River Betsiboka. In various cases black- and red-fronted skins are known from the same localities, viz., Betsako (and Ambundubé in the same neighbourhood)*, Anorontsanga, Ambatondrazaka (Tramond). The following black-headed specimens have been examined:—Ambatondrazaka (coll. Tramond—Mus. Berlin); “N.W. Madagascar,” probably from north of the Bay of Bombétoka (Mus. Berlin—coll. van Dam); Anorontsanga, south of the Bay of Ampasindava (Brit. Mus.—coll. Last †); Ambundubé, near Betsako, Bay of Bombétoka, N. bank (Mus. Frankfurt—coll. Voeltzkow).

The specimens determined as *L. fulvus* subsp. from Andranolava, Upper Bemarivo River, by Kaudern ‡, apparently represent the black-headed type. The assumed smaller size of the specimens from Ste. Marie de Marovoay is not supported by the measurements given.

Black-headed specimens have also been recorded by Pollen and van Dam from the Bay of Bombétoka, the Bay of Mahajamba, and the Antamba River, on the N.W. coast.

LEMUR FULVUS MAYOTTENSIS Schlegel §.

Specimens examined, 4, all from Mayotte Island (Paris Mus. 1; Brit. Mus. 2; Berlin Mus. 1).

This island race of *L. fulvus* cannot be with certainty diagnosed, although there is little doubt about its being entitled to subspecific rank. More material is necessary to settle its real status. In the specimens I have seen the supra-orbital marks are very indistinct and the general colour, although subject to considerable variation, paler and less greenish than in *L. f. fulvus* and distinctly lighter than in *L. f. albifrons*. For the present I have not included it in the analytical key.

LEMUR MONGOZ Linnæus.

Two local races.

- A. A large palatine sinus which projects into the orbit. A white- and a red-cheeked phase, generally sex-linked. Anal region almost naked. *L. m. mongoz* ^{reus.}
 B. No palatine sinus. Palatine slightly inflated. Males with red, females with whitish cheeks. Anal region thickly haired *L. m. coronatus* ^{ay.}

LEMUR MONGOZ MONGOZ Linnæus ¶.

Syn. *nigrifrons* E. Geoffroy, *albimanus* E. Geoffroy, *anjouanensis* E. Geoffroy, *mongous* Muirhead ||, *dubius* F. Cuvier, *micromongoz* Lesson, *Brissonii* Lesson, *ocularis* Lesson, *Cuvieri* Lesson, *Brissonianus* Gray, *johannæ* Trouessart, *mongos* Elliot.

* *Lemur mongoz nigrifrons* Lorenz, Abh. Senckb. xxi. p. 449 (1898).

† True *rufus* has been recorded by Pollen and van Dam from Anorontsanga, Mus. H. N. Pays-Bas, xi. p. 71 (1892).

‡ Ark. Zool. ix. p. 47 (1915).

§ 1866. *Lemur mayottensis* Schlegel, Nederl. Tijdschr. Dierk. iii. p. 76 (Mayotte). All these specimens were collected at Jongoni Bay, Mayotte Island, by Pollen and van Dam in 1864 (Schlegel, Mus. H. N. Pays-Bas, vii. p. 508 (1876)).

|| 1819. “*M[aki] mongous* Desmarest,” Muirhead, Edinburgh Encyclop. 405; ex Desmarest, Nouv. Dict. Hist. Nat. (2 ed.) xviii. p. 437 (1817).

¶ 1904. *Lemur mongos johannæ* Trouessart, Cat. Mamm. Suppl. pp. 1-38.

This species, which occasionally comes to Europe alive, where it is confounded with *L. fulvus* or *L. m. coronatus*, is a distinctly smaller animal than *L. fulvus*, and always easily distinguishable by the pale muzzle. In the red-cheeked phase there is not the black crown-patch found in the male of *L. m. coronatus*, whereas in the white-cheeked phase the colour of the cheeks is brighter than in the female of *L. m. coronatus*, and a large black or blackish crown-patch developed which is absent in that race. The tail is grey or blackish in both sexes in *mongoz*; in *coronatus* it is reddish in the female. As far as my experience goes the males invariably have red and the females white cheeks in all specimens from Anjouan and Moheli, Comoro Island. In specimens from the mainland of Madagascar* this character is not sex-linked†, although, except that, there is no other cranial or external character to distinguish them from the Comoro specimens, it remains doubtful whether this should be sufficient reason to separate the two populations into distinct races.

All the names published up to now refer to the Anjouan animal. The fairly complicated synonymy is as follows:—

1766. *Lemur Mongoz* Linnæus. Based on the coloured plate of a female specimen without history, seen alive in the possession of a Mrs. Kennion by Edwards‡. Represents the white-cheeked female.
1812. *Lemur nigrifrons* E. Geoffroy. Both description and quotation are taken from Petiver§. The animal represented on Petiver's plate is a female specimen of the Anjouan species. There is no type in the Paris Museum, the specimen labelled as such (Mus. Paris; Gallery, no. 86, ♀; from the Menagerie. "Type de Geoffr.") is the same species, but, as the date indicates, not the original specimen.
1812. *Lemur albigannus* E. Geoffroy. Type in the Paris Museum, no. 113 (Gallery), ♂ juv., Anjouan; Péron et Lesueur. "Apporté par la Corvette 'Le Gray' en l'an XII." (1802). This is a male specimen with grey back and red cheeks.
1819. *M[aki] mongous* Muirhead is a latinization of Desmarest's *Maki mongous* and perfect synonym of *Lemur mongoz* Linnæus.
1834. [*Lemur*] *Dubius* F. Cuvier is a female specimen from Anjouan. I have not been able to trace the type, which was a living specimen, and was said to have died in the Jardin des Plantes, Paris.
1840. *Prosimia micromongoz* Lesson||. The description is a copy of *Lemur mongoz* E. Geoffroy¶, which is the same as *Lemur mongoz* Linnæus.
1840. *Prosimia bugi* Lesson is based on Petiver's description and plate "... *cercopithecus indicus Buyec*," which had previously been named *Lemur nigrifrons* by E. Geoffroy.

* In Madagascar itself this race has been found on the south bank of the River Betsiboka, Bay of Bombetoka, by Voeltzkow: but a specimen collected, by M. Tramond, and kindly lent for examination by Herr Flemming of Hamburg, from Ambotondrazaka, Sihanaka country, south-west of Lake Alaotra, shows a considerably greater extension of the range on the dry plateau.

† v. Lorenz, Abh. Senckb. Ges. xxi. p. 450 (1898) (" *Lemur albigannus* ").

‡ *The Mongoz*, Edwards, 'A Natural History of Birds,' v. (= Gleanings of Natural History, i.) p. 12, pl. ccxvi. (1758).

§ *Simia Sciurus lanuginosus fuscus* Petiver, *Gazophylacii Naturæ et Artis*, Decas 1, p. 4, Tab. xvii. fig. 5 (1767). I have only seen this edition. Schreber's plate xlii. is a coloured copy of Petiver's original.

|| Spec. Mamm. p. 226.

¶ Ann. Mus. Paris, xix. p. 226 (1812).

1840. *Prosimia Brissonii* Lesson is based on Brisson's * *Prosimia pedibus albis* in the Museum Réaumur; a white-headed, *e. g.*, female, specimen of the Anjouan form.
1840. *Prosimia ocularis* Lesson is based on various sources. The first quotation, which is *Lemur nigrifrons* E. Geoffroy (= *L. m. mongoz* Linnæus), is now taken as typical.
1870. *Lemur Cuvieri* Fitzinger is based on a red-cheeked male specimen brought from Anjouan to Paris alive by Houssard, and described by F. Cuvier under "*L. Mongous*" †.
1870. "*Propithecus Brissonianus* Lesson" Gray ‡ is an emendation of *Prosimia Brissonii* Lesson.
Nom. nud.; a mounted specimen in the Paris Museum (Gallery) bears the inscription *johannæ*.
1907. *Lemur mongoz* Elliot § is an error for *mongoz* Linnæus.

Specimens examined, 44 :—

Anjouan Island (Berlin, Paris, and Brit. Mus.).

Moheli Island (Berlin and Brit. Mus.).

Madagascar, : Antema, Bay of Bombétoka, S. bank (Mus. Frankfurt—coll. Voeltzkow); Ambatondrazaka, south of Lake Alaotra (property of Herr Flemming—coll. Tramond).

This race is found on the Comoro Islands, Anjouan and Moheli, but not on Mayotte, where only a race of *L. fulvus* occurs, which, however, is absent on Anjouan and Moheli. There is no record up to now of the occurrence of a Lemur on any other island of the group. On the mainland of Madagascar this form is found on the south bank of the Betsiboka River, which it ascends up to its head-waters. It does not occur on the north bank of the river, where it is replaced by *L. m. coronatus* Gray.

LEMUR MONGOZ CORONATUS Gray.

Syn. *chrysampyx* Schuermans.

This race of *L. mongoz* is found in northern Madagascar, both in the east and west, north of the bays of Bombétoka and Antongil respectively.

Specimens examined, 10 :—

Vohémar, N.E. coast (Mus. Berlin, Brit. Mus.); Ampasimbato, Central N. Madagascar (14° 2' 30" S., 47° 46' 0" E.) (Mus. Berlin); Amber Mts. (Mus. Berlin); Bay of Mahajamba, N.W. coast (15° 14' S.) (Brit. Mus.—*type of coronatus*) ||.

Type of *Lemur coronatus* Gray; Brit. Mus. no. 37.9.26.30, old ♂; collected during the voyage of the 'Sulphur,' between March 9 and 15, 1843 ||.

LEMUR RUBRIVENTER I. Geoffroy.

Syn. *flaviventer* I. Geoffroy, *rufiventer* Gray ¶, *rufipes* Gray.

Type-specimens :—

rubriventer : Paris Museum, no. 1834-88, Gallery, no. 64, ♂ juv., "Madagascar"; Bernier, 1834; mounted skin, skull inside.

* Règn. Anim. (2) p. 156 (1762).

† Hist. Nat. Mamm. livr. ii. p. 2 (January 1819).

‡ Cat. Monkeys, Lemurs, etc. B. M. p. 75.

§ Publ. Field Col. Mus., Zool. viii. p. 544 (1907).

|| Hinds, Zool. Voy. 'Sulphur,' p. 6 (1843).

¶ Cat. Monkeys, Lemurs, etc. B. M. p. 74 (1870) (err. pro *rubriventer*).

flaviventer : Paris Museum, Gallery, no. 67, ♀ ad., "Madagascar" (probably Tamatave, E.S.); Goudot, 1842; mounted skin, skull inside. Lectotype (here selected).

rufipes : British Museum, no. 70.5.5.35, ♂ : Betsimisaraka country, probably west of Tamatave*, A. Crossley; skin and skull. Lectotype (here selected).

Specimens examined, 32 :—

Vohémar, N.E. coast (Mus. Paris); Bay of Antongil (Mus. Paris); Betsimisaraka country, west of Tamatave (Brit. Mus.—coll. A. Crossley—incl. type of *rufipes*); Tamatave, N.E. coast (Brit. Mus.); Forest of Ankay, N.E. of Tananarive (Brit. Mus.—coll. Robillard); Ambohimombo and Ivohimanitra, N. Tanala country (Brit. Mus.—coll. Major); Vinanitelo, S.W. Betsileo (Brit. Mus.—coll. Major); Manakara River, S.E. coast (Mus. Paris—coll. Grandidier); Kazoaka, Upper Manakara River (Mus. Berlin—coll. Audebert); Mojanga, Bay of Bombétoka, N. bank (Mus. Berlin); Morondava, W. coast (Mus. Paris—coll. Lantz).

If all these records are correct the range of *L. rubriventer* includes the greater part of Madagascar, not only the eastern forest region, as has hitherto been supposed.

LEMUR MACACO Linnæus.

Syn. *niger* Schreber, *leucomystax* Bartlett.

The type of *Lemur leucomystax* is in the British Museum (no. 67.10.5.15, old ♀; Zool. Soc.; skin and skeleton). This is a rich chestnut female of quite typical appearance.

There is a certain amount of individual variation in the colour of the females from rusty brown to dark brownish grey; the same is true of the colour of the crown, which may or may not be black or blackish. Except the museum material a great number of living specimens have been observed alive, among which was a good series at Herr L. Ruhe's establishment at Alfeld, near Hanover, which was imported this year. A tendency to become darker in captivity can be generally observed.

Museum specimens examined, 12 (mostly from "Madagascar.") The dated specimens in the Berlin Museum are collected by J. M. Hildebrandt at Loko bé, Nosy bé, Island, N.W. Madagascar.

The range of *L. macaco* is limited to the forests of the N.W. coast, north of the Bay of Bombétoka and the coast islands. It has been recorded by Pollen and van Dam from the following places :—Anorontsanga; Syrangene; Kongony and Jangoa Rivers; Andoany, Narendry Bay ("Macroandiana").

LEMUR VARIEGATUS Kerr.

Syn. *ruber* E. Geoffroy, *vari* Muirhead †, *erythromela* Lesson ‡, *varius* I. Geoffroy.

I am rather disinclined to believe in the great individual variation in this species which Elliot maintains. If a series from one single locality is examined the rule is that they are more or less alike. The general types found have been

* From A. Crossley's 1869 expedition from Tamatave to Ambatondrazaka.

† 1819. "*M[aki] vari Desmar.*", Muirhead, Edinburgh Encyclop. xiii. p. 405, ex *Le Maki vari Desmarest*, Nouv. Dict. Hist. Nat. (2 ed.) xviii. p. 437 (1817).

‡ 1840. *Prosimia erythromela* Lesson, Spec. Mamm. p. 236.

well described by I. Geoffroy St. Hilaire *, but at least three of them were known long before that, and were described and figured in 1797 by Audebert. It would appear that most of them are geographical races. As a more detailed account of the genus *Lemur* is prepared a reference to I. Geoffroy's description and Milne-Edwards's and Grandidier's plates will be sufficient †.

At present it appears that three races can be distinguished, of which I. Geoffroy's "variety *a*" lives north of the Bay of Antongil, "var. *c*" on the east coast, south of the Bay of Antongil, and "variety *b*" on the plateau of the interior; three specimens of this last type from Ambotondrazaka, south of Lake Alaotra, are before me. The red animal is a colour mutation of "variety *a*" with which it occurs and interbreeds. Crosses between the two which have been born at the Berlin Zoo are much like some of Milne-Edwards's and Grandidier's plates ‡. Until more material with exact localities is available for comparison a naming of these races is postponed. All the names published until now refer to either the black and white or the red mutation of the north-eastern race.

Specimens examined, 41; also a great number of living specimens, all of "var. *a*" or "*ruber*."

N.E. coast (Mus. Paris—coll. Crossley) ("*ruber*"); Tombato River (Mus. Paris—coll. Lantz) ("*ruber*"); Sakana, opposite the Ile Ste. Marie (Mus. Berlin—coll. Voeltzkow, 6 skins) ("var. *c*"); Alumanitra Forest (Mus. Paris—coll. Grandidier) (var. *b*); Bay of Antongil (Mus. Paris—coll. Lantz) ("var. *c*"); Ambatondrazaka (lent by Flemming, Hamburg—coll. Tramond, 3 skins) ("var. *b*"); "Madagascar" (Brit. Mus.).

Black and white and red specimens have been collected in the same place by J. Audebert in the coast region north of the Bay of Antongil §. Red specimens are recorded from Maroansetra, Bay of Antongil; Malewo and Andranofotsy, N.E. coast, north of the Bay of Antongil. As I have not seen these specimens I cannot say to which of I. Geoffroy's "varieties" the black and white skins belong; the localities are the following: Mananare, Bay of Antongil; Maroansetra, Bay of Antongil; Sahambavany ("*Savary*"), N.E. coast, north of the Bay of Antongil; Mahombo, between Fénerive and Foulpointe, East coast; Vohidrotra, north of Tamatave, East coast. The living specimen figured by Kaudern || from Fénerive, East coast, represents "var. *c*."

From the material at hand it would thus appear that *Lemur variegatus* is restricted to the forests of N.E. Madagascar. Its northern limit may be about 13° 30' S., its southern range has been ascertained as the region of Tamatave at about 18° S. I have not been able to verify Elliot's record from Masindrano, and do not know where he took it from. On the plateau Ambatondrazaka remains the only place known.

All the names published up to now refer to "var. *a*" and its red mutation.

Lemur variegatus Kerr is based on Buffon's plate ¶ of an animal which he apparently saw alive, and of which he described the anatomy.

* Cat. Méth. Mamm. Mus. Paris, p. 71 (1851).

† Hist. Phys. Nat. Pol. Madagascar, x. tome v. pls. cxxiii. ("var. *a*"), cxxiv. (["var. *b*"]), cxxv. ("var. *c*"), cxxviii. ("*ruber*") (1890).

‡ L. c. pls. cxxvi., cxxvii.

§ Jentink, Mus. H. N. Pays-Bas, xi. pp. 65-66 (1892).

|| Ark. Zool. ix. no. 18, p. 43, pl. iii. (1915).

¶ Buffon, Hist. Nat. xiii. p. 204, pl. xxvii. (1765); this plate has been copied by Schreber,

Maki vari Muirhead is based on Desmarest's description, which quoted both of Audebert's plates representing "var. *a*" and "*c*" and described in detail a specimen of "var. *a*" formerly in the possession of the Empress Joséphine at Malmaison and now in the Paris Museum (Gallery, no. 42, "Madagascar"; presented 1809). This name is now formally restricted to "var. *a*."

Lemur ruber E. Geoffroy is based on a drawing of the red mutation brought home by Commerson.

Prosimia erythromela Lesson is simply a new name for *L. ruber*.

Lemur varius I. Geoffroy includes all the colour-types known except the red one, and is now restricted to "var. *a*."

LEPILEMUR I. Geoffroy.

1851. *Lepilemur* I. Geoffroy, Cat. Méthod. Mamm. Mus. Paris, p. 75.

Type by monotypy, *Lepilemur mustelinus* I. Geoffroy.

1855. *Galeocebus* Wagner, Schreber, Säugeth., Suppl. v. p. 147.

Type by monotypy, *Galeocebus mustelinus* Wagner=*Lepilemur mustelinus* I. Geoffroy.

1875. *Mixocebus* Peters, Mb. Ak. Berlin, 1874, p. 690.

Type by monotypy, *Mixocebus caniceps* Peters=*Lepilemur mustelinus* I. Geoffroy.

1875. *Lepidolemur* Peters, l. c. p. 690 (emend. e *Lepilemur* I. Geoffroy).

Two species.

- | | |
|---|------------------------------------|
| A. Size larger. Ground-colour essentially brown. Tail short, dark. | <i>L. mustelinus</i> I. Geoffroy. |
| B. Size smaller. Colour greyish brown or brownish grey. Tail longer, paler at tip | <i>L. ruficaudatus</i> Grandidier. |

LEPILEMUR MUSTELINUS I. Geoffroy.

Syn. *caniceps* Peters, *microdon* Major.

Forsyth Major has separated from *mustelinus* a number of skulls with smaller teeth and with a different coloration. The series later on collected by himself in various parts of eastern and central Madagascar disproves his own views. As a matter of fact, a large- and a small-toothed type can be distinguished, and also, according to coloration, (1) a type with a pale brown back, hardly any nuchal stripe, dark grey head, and the lower side almost without yellow, and (2) a type with golden-brown back, with a distinct nuchal stripe, with brown head, the sides of the neck yellowish, and the lower side yellowish brown. Forsyth Major maintained that the small-toothed skull was found associated with the second, and the large-toothed skull with the first colour phase. But the material at hand clearly shows that this is not the case. Moreover, both the large-toothed (*mustelinus*) and the small-toothed (*microdon*) skull are found together in the same places. I have no doubt, therefore, that *microdon* is a clear synonym of *mustelinus*.

The type of *Mixocebus caniceps* Peters in the Berlin Museum is a mounted subadult female in fair condition, with the skull separate. The skull represents the small-toothed type. All the cheek-teeth are in position but not worn; the upper canines are not fully developed, their tips being on about the same level as those of P². The basal suture is still open. The two upper incisors, upon which *Microcebus* has been founded, are the dI¹ described elsewhere for the young *Lepilemur*. The type-locality cannot be given with certainty; apparently the specimen was collected in 1872. At that time Crossley, the

collector, was exploring the east coast of Madagascar between Tamatave and Masindrano.

The type of *Lepilemur mustelinus* was collected by Goudot, who at that time was collecting at or near Tamatave. This place should be taken as the type-locality.

The range of *L. mustelinus* includes the moist east and north-east of Madagascar, at least as far south as Betsileo and as far north as Vohémar. It does not occur in the north-west, where *L. ruficaudatus* is found.

Specimens examined, 27, including the types of *caniceps* and *microdon*, from the following localities :—

Vohémar, N.E. coast (Mus. Berlin); Ankay Forest, N.E. of Tananarive (Brit. Mus.); Ampitambé and Antsiraka, Betsimisaraka country (Brit. Mus.); Ankona Forest ("Ankafina Forest"); Upper Masiatra River, E. Betsileo (Mus. Berlin—coll. Hildebrandt, and Brit. Mus.—coll. Cowan); Vinanitelo, S.W. Betsileo (Brit. Mus. and Mus. Tring).

LEPILEMUR RUFICAUDATUS Grandidier.

Syn. *dorsalis* Gray, *pallidicauda* Gray, *edwardsi* Major, *globiceps* Major, *grandidieri* Major, *leucopus* Major, *rufescens* Lorenz*.

The following type-specimens have been examined :—

- dorsalis* : Brit. Mus. no. 68.9.7.5, ♂ "N.W. Madagascar"; van Dam; skin.
pallidicauda : Brit. Mus. no. 72.8.19.7, ♂, Morondava, W. coast; Crossley, skin and skull.
edwardsi : Brit. Mus. no. 91.1.22.6, ♂, Betsako, north bank, Bay of Bombétoka, N.W. coast; J. T. Last, skin and skull.
globiceps : Brit. Mus. no. 92.11.6.1, ♂, Ambolisatra, 25 km. north of Tuléar, S.W. coast; J. T. Last; body in alcohol and skull.
grandidieri : Brit. Mus. no. 68.9.7.4, ♀, "N.W. Madagascar"; van Dam, skin and skull.
leucopus : Brit. Mus. no. 94.1.22.1, ♂, Ft. Dauphin, S.E. coast; A. Boucard, skin and skull.
rufescens : Senckenberg Museum, Frankfurt-a.-M. no. 727 (orig. no. 89), ♂, Ambundubé, north bank, Bay of Bombétoka, N.W. coast; A. Voeltzkow, skin and skull.

Of these names *dorsalis*, *edwardsi*, *grandidieri*, and *rufescens* are based on specimens from the same general region north of the Bay of Bombétoka, N.W. coast; *dorsalis* and *grandidieri* are even based on specimens with exactly the same history; *ruficaudatus* and *pallidicauda* have the same type-locality, viz., Morondava, W. coast, and *globiceps* is from the same general region, only farther south. The type-locality of *leucopus*, Ft. Dauphin, S.E. coast, is the extreme point where the south-western dry fauna occurs. The type-specimen is in every respect typical *ruficaudatus*.

Specimens examined, 18, including the above types, from the following localities :—

Loko-Bé, Nosy Bé Island, N.W. Madagascar (Mus. Berlin—coll. Hildebrandt); "N.W. Madagascar," probably from the Bay of Ampasindava or the Bay of Mahajamba (Brit. Mus.—coll. van Dam, types of *dorsalis*

* 1898. [*Lepilemur*] *mustelinus rufescens* Lorenz, Abh. Senckb. Ges. xvi. p. 446, Taf. xxx., xxi. figs. 4 a, b. (Type locality: Ambundubé, north side of the Bay of Bombétoka, N.W. Madagascar).

and *grandidieri*); Betsako, north bank, Bay of Bombétoka (Brit. Mus.); Ambundubé, near Betsako (Senckb. Mus.—type of *rufescens*); Antema and Kandani, south bank, Bay of Bombétoka (Senckb. Mus.—coll. Voeltzkow); Morondava, W. coast (Brit. Mus. and Mus. Berlin); Ambolisatra, S.W. coast (Brit. Mus.); “S.W. Madagascar” (Mus. Tring—coll. J. T. Last); Ft. Dauphin, S.E. coast (Brit. Mus.).

This species has also been recorded by Pollen and van Dam from various points on the N.W. coast: Anorontsanga, Jangoa River, Ampasindava, all at or near the Bay of Ampasidava; also from the Bay of Mahajamba. The range, therefore, covers the entire west coast, including the north-west and south-east, but not the central plateau. The northern and eastern limits remain to be ascertained.

PROPITHECUS Bennett.

1832. *Propithecus* Bennett, P. Z. S. p. 20.

Type by monotypy, *Propithecus diadema* Bennett.

1833. *Macromerus* A. Smith, S. Afr. Quart. Journ. ii. no. 1, part 2, p. 49.

Type by monotypy, *Macromerus typicus* A. Smith—*Propithecus diadema* Bennett.

Two species.

- | | |
|---|---------------------------------|
| A. Size larger. Tail not projecting beyond heel. Fur loose | <i>P. diadema</i> Bennett. |
| B. Size smaller. Tail projecting beyond heel. Fur not loose | <i>P. verreauxi</i> Grandidier. |

A specimen in alcohol of *Propithecus verreauxi coquereli* Grandidier, which had lived at the Berlin Zoo in 1912 (Mus. Berlin no. 16165), has neither carpal nor interramal vibrissæ, thus confirming Pocock's suggestion*.

PROPITHECUS DIADEMA Bennett.

4 local races.

- | | |
|---|-------------------------------|
| A. Body-colour white or grey. | [Grandidier] |
| a. General colour white, only head occasionally grey | <i>P. d. candidus</i> |
| b. General colour grey. Head blackish, limbs yellow | <i>P. d. diadema</i> Bennett. |
| B. Prevailing colour black or brownish black. | [Grandidier.] |
| c. Lower back creamy; pygal triangle dark brown | <i>P. d. edwardsi</i> |
| d. Upper surface entirely black. Pygal triangle reddish brown | <i>P. diadema holomelas</i> |
| | [Gunther] |

PROPITHECUS DIADEMA CANDIDUS Grandidier.

Syn. *sericeus* A. Milne-Edwards and Grandidier.

The original name *candidus* was changed by the author into *sericeus*; but the first name will have to stand. The type-locality of *sericeus* should be taken as typical for *candidus*.

Type-locality.—Sahambavany, N.E. coast; type collected by M. Guinet, 1872.

Specimens examined, 6:—

Sahambavany, N.E. coast (Brit. Mus.—coll. Crossley); Antsompirina and Ansandrizina, N.E. coast † (Mus. Berlin—coll. J. Audebert).

* P. Z. S. 1918, p. 25.

† I have not been able to trace these two localities on any map; but as the Lalo River (15° 23' 0" S., 48° 5' 50" E.) and Nosy Voara (15° 27' 0" S., 48° 6' 30" E.) are amongst Audebert's localities when he made this particular collection, I expect these two localities to be on the peninsula which forms the eastern border of the Bay of Antongil, approximately between Angontey and Cape Masoala.

The range of this race includes the north-eastern coast ranges of the island from the region of Bemarivo ($14^{\circ} 16' 30''$ S.), which is the northernmost locality recorded, to the Bay of Antongil; I suppose the Tsingambala River, at the northern end of the bay, will be found to separate the range of *candidus* from that of *diadema*.

PROPITHECUS DIADEMA DIADEMA Bennett.

Syn. *typicus* A. Smith, *albus* Vinson*.

Type of *Propithecus diadema*: Brit. Mus. no. 55.12.24.48, ♂ subad.; Ch. Telfair coll.; skin and skull. No locality.

Specimens examined, 15, in the Berlin, British, and Tring Museums, including the type, but mostly without locality. Specimens with definite locality from Tamatave, N.E. coast (Brit. Mus.—coll. G. C. Addison-Williamson); Andragoloaka, S.E. of Tananarive (Mus. Berlin—coll. Hildebrandt).

According to Milne-Edwards and Grandidier† this race is found in the mountain forests of the coast range of East Madagascar from the Bay of Antongil as far south as the Masora River, south of Mahanoro (about 20° S.), which separates its range from that of *P. d. edwardsi*.

Recorded by J. Audebert ‡ from Mananare, Bay of Antongil.

PROPITHECUS DIADEMA EDWARDSI Grandidier.

Syn. *bicolor* Gray.

Type-locality.—East of Masindrano, S.E. Madagascar.

Two specimens in the British Museum were labelled as co-types of *Propithecus bicolor* Gray. They were mounted, but have recently been made into skins. N. 72.8.19.1, ♂ (skin and skull) is now selected as lectotype, no. 72.8.19.2 remaining a paratype. Both specimens are typical *edwardsi*. They were purchased from E. Gerrard, Jr., and probably collected by Crossley on his 1872 trip between Masindrano and Mahanoro. As the specimens in the Leiden Museum obtained from Frank, but obviously also collected by Crossley, are from Masindrano (Mananjara), this locality may be taken as typical.

Specimens examined, 22 :—

Ampitambé, Betsimisaraka country (Brit. Mus.—coll. Major); Ivohimanitra, Tanala (Brit. Mus.—coll. Major); Ambohimombo, N. Tanala (Mus. Tring—coll. Major); Vinanitelo, S.W. Betsileo (Brit. Mus.—coll. Major); also 13 without definite locality (Brit. Mus. and Berlin Mus.).

According to A. Milne-Edwards and Grandidier this race is found in the mountain-forest along the south-east coast between the Masora (20° S.) and Matitana Rivers (about 22° S.). The specimens from Vinanitelo would indicate a considerable extension of the range on the central plateau.

PROPITHECUS DIADEMA HOLOMELAS Günther.

Type: Brit. Mus. no. 75.7.20.2, ♀, "Madagascar," A. Crossley; skin and skull. Lectotype (here selected).

Type-locality.—Probably Fianarantsoa, Central Betsileo, where all of Crossley's dated specimens of this race were collected.

* Type-locality: Analamazaotra, between Andevoranto and Tananarive, E. Madagascar.

† Hist. Phys. Nat. Pol. Madagascar, ii. tome i. p. 300 (1875).

‡ Jentink, Mus. H. N. Pays-Bas, xi. p. 61 (1892).

Specimens examined, 12 :—

Fianarantsoa, Centr. Betsileo (Mus. Tring and Berlin) ; S. Betsileo (Mus. Berlin—coll. Hildebrandt) ; Nandihizana, N. Betsileo (Mus. Berlin—coll. Hildebrandt) ; “Ambavombé” *), south of Ft. Dauphin, S. coast (lent by Flemming—Hamburg).

The range of this race appears to be the inland mountain range in the south-east of Madagascar, whereas *P. d. edwardsi* inhabits the coast range. I have little doubt as regards the distinctness of the two races. Intermediate specimens (B.M. 75.1.29.6–7) are known ; they should occur in localities intermediate between the two ranges.

PROPITHECUS VERREAUXI Grandidier.

Six local races.

- A. Crown not black or blackish brown.
 - a. All white *P. v. deckeni* Peters.
 - b. Inside of limbs chestnut-brown. Lower side tinged with rufous . . . *P. v. coquereli* Grandidier.
- B. Crown of head black or blackish brown.
 - c. Limbs white. Back at most tinged with pearl-grey. [A. Milne-Edwards.
 - a¹. Lower surface, at least breast, rusty red. Nails very broad. *P. v. coronatus*
 - b¹. Lower surface white. Nails small *P. v. verreauxi* Grandidier
 - d. Inside of limbs and greater part of back chocolate-brown . . . *P. v. majori* Rothschild.

PROPITHECUS VERREAUXI COQUERELI Grandidier.

Syn. *damonis* Gray †.

Type-locality not given in original description, nor by any subsequent author. Collected by Dr. Coquerel.

Specimens examined, 11 :—

Betsako, N. bank, Bay of Bombétoka (Brit. Mus.—coll. Last ; Frankfurt Mus.—coll. Voeltzkow) ; Ambundubé near Betsako (Mus. Frankfurt—coll. Voeltzkow) ; Island Nosy Komba (Mus. Berlin—coll. Hildebrandt) ; Ambatondrazaka, south of Lake Alaotra (lent by Herr Flemming—coll. Tramond).

Recorded by Kaudern ‡ from various places between the Rivers Betsiboka and Mahajamba. According to A. Milne-Edwards and Grandidier § the range is delimited by the River Antamba (Loza), Bay of Narenday, in the north, and the River Betsiboka in the south. The specimen from Ambatondrazaka before me shows an eastern extension of the range as far as Lake Alaotra.

PROPITHECUS VERREAUXI CORONATUS A. Milne-Edwards.

Syn. *damanus* Schlegel ||.

Specimens examined, 10 :—

“N.W. Madagascar” (Brit. Mus.) ; Kandani, Bay of Bombétoka, south bank (Mus. Berlin and Frankfurt—coll. Voeltzkow) ; Bay of Bombétoka, south bank (Mus. Berlin—coll. van Dam ; probably of the original series).

Recorded by Kaudern ¶ from Ankaboka, Katsepy, and the Boina Mountains. Distribution between the Besiboka and Mahavavy Rivers.

* Not traced on the map ; possibly Mt. Andrahomanana (“Andrahombé”).

† Cat. Monkeys, Lemurs, etc. B. M. p. 137 (1870). Type in British Mus. no. 70.8.8.1.

‡ Loc. cit. p. 4. § Loc. cit. p. 316.

|| Mus. H. N. Pays-Bas, vii. p. 295 (1876) (S. bank of the Bay of Bombétoka). ¶ Loc. cit. p. 6.

PROPITHECUS VERREAUXI DECKENII Peters.

Type: Museum Berlin, no. 3466, ♀ juv., Kanatsy, N.W. Madagascar, v. d. Decken; mounted skin and skull.

Specimens examined, 12 :—

Kanatsy, 17° 54' S., N.W. coast (Mus. Berlin—coll. v. d. Decken); Beravina, 17° 10' S., N.W. coast (Mus. Berlin—coll. Hildebrandt), plains north of Ankavandra, Central N.W. Madagascar (Mus. Berlin and Brit. Mus.—coll. Crossley).

Recorded by Kaudern from Betsina, south bank of Lake Kinkony*. According to Milne-Edwards and Grandidier † this race is found only between the Rivers Mahahavy (Manzaray) and Mananbolo.

PROPITHECUS VERREAUXI VERREAUXI Grandidier.

Type-locality.—Tsifanihy, Prov. Antandroy, north of Cape Ste. Marie, S. Madagascar.

Specimens examined, 10 :—

Tuléar, S.W. coast (Brit. Mus.); Morondava, W. coast (Mus. Berlin—coll. van Dam); Bemamanga near Morondava (Mus. Frankfurt—coll. Voeltzkow); Antanosy country ‡ (Brit. Mus. and Mus. Tring—coll. Last); Ankazoabo, Central S.W. Madagascar (Brit. Mus.).

According to A. Milne-Edwards and Grandidier § the range of *P. v. verreauxi* includes the whole south-western part of Madagascar from the Tsidsobon River on the west coast to the region of Ft. Dauphin in the south-east. Nothing is known of the exact limits of the range, neither in the east, where it should meet *P. d. holomelas*, nor in the west, where no record exists for the region between the Mananbolo and Tsidsobon Rivers, where either this race or *P. v. deckenii* should occur.

PROPITHECUS VERREAUXI MAJORI Rothschild.

Type in Tring Museum; mounted skin; collected by J. T. Last, and received in November 1893; no skull; country of the emigrated Antanosy, S. Central Madagascar.

There are four more skins exactly like the type in the Tring Museum.

The original label only says "Antinosy" (=Antanosy) country. It would appear that this means the mountain range round and east of Manansoa (23° 3' S., 44° 50' E.), where J. T. Last was collecting in 1889 ||. The specimens of true *verreauxi* collected by Last and also labelled "Antinosy country" are probably from the plains farther west, and collected on the way to or from Tuléar, on the S.W. coast. Only the original series of this race is known.

INDRI E. Geoffroy & G. Cuvier.

1795. *Indri* E. Geoffroy & G. Cuvier, Mag. Encyclop. (2) i. p. 46.

Type by tautonymy, *Lemur indri* Gmelin.

1800. *Indris* G. Cuvier, Leçons Anat. Comp. i. Tabl. gén. (emend. ex *Indri*).

* Ark. Zool. ix. no. 18, p. 6 (1915).

† Country of the "Antanosy émigrés."

|| Geogr. Journ. vi. pp. 249–52, 2 maps (1895).

‡ *Loc. cit.* p. 314.

§ *Loc. cit.* p. 312.

1811. *Lichanotus* Illiger.

Type ab initio *Lemur indri* Gmelin *.

1815. *Indrium* Rafinesque, *Analyse Nat.* p. 54 (nom. nov. pro *Indri* E. Geoffroy and G. Cuvier).

1827. *Lichanotes* Temminck, *Mon. Mamm.* p. xvi (err. pro *Lichanotus* Illiger).

1840. *Pithelemur* Lesson, *Spec. Mamm.* pp. 207, 208.

Type by monotypy, *Lemur indri* L.

INDRI INDRI Gmelin.

Syn. *brevicaudatus* E. Geoffroy, *niger* Lacépède, *ater* I. Geoffroy †, *mitratus* Peters, *variegatus* Gray.

The names *indri*, *brevicaudatus*, *niger*, and *ater* are based on Sonnerat's specimen ‡. This is an animal with dark brown arms and legs, and without a parieto-occipital band, but with indistinct superciliary marks.

Type (lectotype) of *Lichanotus mitratus* Peters, *Mus. Berlin*, no. 4671, ♂, probably from the Lalo River, east of the Bay of Antongil; coll. Crossley; skin and skull. This is a specimen with light buff-grey arms, whitish-grey lower legs, fairly distinct brow-marks, and a conspicuous creamy-white parieto-occipital band.

Type of *Indris variegatus* Gray, *Brit. Mus.* no. 72.11.8.12, ♀, (Cutter); collected by Crossley; skin and skull. Arms and legs grey, brow-marks present; also a grey parieto-occipital band. Judging by the date of collecting, this specimen should have come with the same consignment as the type of *mitratus*, and may be a topotype of it.

In the long series of specimens at hand the majority have very few pale markings, and, except the brow-band, the paler under surface, the heel-marks, and the pygal triangle, are fairly blackish brown all over. The parieto-occipital band, which was said to be characteristic of *mitratus* and *variegatus*, is extremely variable and absent in topotypes of both. It appears, however, that the specimens from the region east and north of the Bay of Antongil have a tendency to show grey arms and legs, although this is not constant. South of the Bay of Antongil the arms and legs are usually dark brown; there is, indeed, hardly any variation in the fifteen specimens collected at Sakana, north of Tamatave, by Prof. Voeltzkow. If it can be shown that in the northern specimens grey arms and legs are found constantly or only in the majority of the population, *mitratus* Peters would be available for them.

Specimens examined, 40 :-

Vohémar, N.E. coast (*Brit. Mus.*—coll. Crossley); Lalo River, east of the Bay of Antongil, N.E. coast (*Mus. Berlin*; *Mus. Tring*—coll. Audebert); Antsompirina, east of the Bay of Antongil (*Mus. Tring*—coll. Audebert); Sakana, opposite the Ile Ste. Marie, east coast (*Mus. Berlin*—coll. Voeltzkow, 16 skins); Tamatave, east coast (*Brit. Mus.*—coll. Addison-Williamson); Antsihanaka Forest, Lake Alaotra (*Brit. Mus.*—coll. Lamberton).

* Elliot's selection of *laniger* as the type-species (*Publ. Field Col. Mus.*, Zool. viii. p. 543, 1907) cannot be accepted, as *Lichanotus* Illiger is a strict synonym of *Indri*, containing the same two species and being apparently only an alternative term to avoid tautonymy of the generic and specific names (as regards the principle, see Allen, *Bull. Am. Mus. N. H.* xvi. p. 116, 1902, and Thomas, *P. Z. S.* 1906, p. 476). Even if Allen's principle should not be accepted, a formal identification of *Lichanotus* with "*Indris*" has been made as early as 1825 (I. Geoffroy, *Dict. Class. Hist. Nat.* viii. p. 533).

† 1825. *Indris ater* I. Geoffroy, *Dict. Class. Hist. Nat.*, viii. p. 534 (err. pro *niger* Lacépède).

‡ Sonnerat, *Voyage Ind. or. Chine*, ii. p. 142, pl. lxxxviii. (1782).

According to Jentink also recorded from the following places by M. J. Audebert :—Maroansetra, Bay of Antongil ; Mananare, Bay of Antongil ; “Maisine” (probably Fénerive). If Grandidier’s record is correct, as appears to be the case, the southern limit of the range would be about 20° S., *e. g.*, the region of Mahanoro and the Masora River. The range would thus be co-extensive with that of *Lemur variegatus*, covering the entire north-east and reaching to Lake Alaotra on the central plateau.

AVAHI Jourdan.

1834. *Microhynchus* Jourdan, Thèse Fac. Sci. Grenoble (not seen) (not *Megerle*, 1823).

Type by monotypy, *Lemur laniger* Gmelin.

1834. *Avahi* Jourdan, l’Institut, ii. p. 231.

Type by monotypy, *Lemur laniger* Gmelin.

1835. *Avahis* Gervais, Résumé leçons Mammal. I. Geoffroy Saint-Hilaire, p. 23 (emend. ex *Avahi* Jourdan).

1839. *Habrocebus* Wagner, Schreber, Säugth., Suppl. i. p. ix.

Type by subsequent designation *, *Lemur lanatus* Schreber = *Lemur laniger* Gmelin.

1840. *Semnocebus* Lesson, Spec. Mamm. p. 209.

Type by monotypy, *Semnocebus avahi* Lesson = *Lemur laniger* Gmelin.

1841. *Iropocus* Gloger, Gem. Hand- u. Hilfsbuch Naturg. i. p. 43.

Type by monotypy, *Lemur laniger* Gmelin.

AVAHI LANIGER Gmelin.

Two local races.

- | | |
|---|-----------------------------------|
| A. Larger. Basal length of skull 55-58 mm. Tail rusty red. A distinct pygal patch. Lower side slaty grey | <i>A. l. laniger</i> Gmelin. |
| B. Smaller. Basal length of skull about 51 mm. Tail not distinctly red. No distinct pygal patch. Lower side buffy | <i>A. l. occidentalis</i> Lorenz. |

AVAHI LANIGER LANIGER Gmelin.

Syn. *brunneus* Link †, *longicaudatus* E. Geoffroy, *lanatus* Wagner, *avahi* Lesson, *avahi* van der Hoeven, *orientalis* Lorenz ‡.

Except *orientalis* all these names are based on Sonnerat’s “Maki à bourres” §.

Specimens examined, 13 :—

Vohémar, N.E. coast (Mus. Berlin—coll. Crossley) ; Lakato Forest, Ankay, N.E. of Tananarive (Brit. Mus.—coll. Lamberton) ; Ambohitra, Kolaby Forest, N. Betsileo (Brit. Mus.—coll. Lamberton) ; Vinanitelo, S.W. Betsileo (Brit. Mus.—coll. Major) ; Fianarantsoa, Centr. Betsileo (Mus. Tring—coll. Major).

Recorded by J. Audebert from Malewo north, and from Mananare and Mahambo south of the Bay of Antongil ||.

A. l. laniger inhabits the whole forest region of north-eastern, eastern, and south-central Madagascar .

* Elliot, Rev. Primates, i. p. xxix. (1913).

† 1795. *L[emur] brunneus* Link, Beytr. Naturg. i. 2. Stück, p. 65 (nom. nov. pro *laniger*).

‡ 1898. *A[vahis] laniger orientalis* Lorenz, Abh. Senckb. Ges., xxi. p. 452 (ex *Avahi laineus* oriental Milne-Edwards & Grandidier, Hist. Phys. Nat. Pol. Madagascar, vi. tome i. p. 357, also p. 846.—Bay of Antongil (*Avahis laniger*) and ix. tome iv. pl. ix. (*Avahis laniger*) 1875).

§ Voy. Ind. or. Chine, ii. p. 142, pl. lxxxix. (1782).

|| Jentink, Mus. H. N. Pays-Bas, xi. pp. 64-65 (1892).

AVAHI LANIGER OCCIDENTALIS Lorenz.

1875. *Avahis laniger variété septentrionale* Grandidier & Milne-Edwards, Hist. Phys. Nat. Pol. Madagascar, vol. vi. tome i. pp. 328-29. Bay of Ampasindava; distribution between Cap d'Ambre and Anorontsanga).
1875. *Avahi laineux occidental* Grandidier & Milne-Edwards, *l. c.* p. 357 (explanation to vol. ix. tome iv. pl. x. (type from Ampasindava), pl. xlv. figs. 8-10, pl. xlvi. figs. 1-3).
1898. *Avahis laniger occidentalis* Lorenz, Abh. Senckb. Ges. xxi. p. 452 (ex Milne-Edwards & Grandidier).

Specimens examined, 3 :—

"N.W. Madagascar," all north of the Bay of Bombétoka (Brit. Mus. and Mus. Dresden—coll. van Dam).

Collected by van Dam at Kakamba and Ampasidava, N.W. coast*, by Voeltzkow and Ambundubé near Betsako †, and by Kaudern from the Mahajamba River near Ste. Marie de Marovoay ‡. The range of this race includes the north-west coast as far south as the Bay of Bombétoka; the northern and eastern limits are not certain.

DAUBENTONIA E. Geoffroy.

1795. *Daubentonia* E. Geoffroy, Décad. Philos. Litt. no. 28, p. 195.
Type by monotypy, *Sciurus madagascariensis* Gmelin.
1795. *Scolecophagus* E. Geoffroy, *l. c.* p. 196 (nom. alternativ. pro *Daubentonia*).
1799. *Aye-aye* Lacépède, Tabl. Mamm. p. 6.
Type by monotypy (and tautonymy: *Aye-aye*, Sonnerat) *Sciurus madagascariensis* Gmelin.
1800. *Cheiomys* G. Cuvier, Leçons Anat. Comp. Tabl. i.
Type by monotypy, *Sciurus madagascariensis* Gmelin.
1803. *Cheyromys* E. Geoffroy, Cat. Mamm. Mus. H. N. Paris, p. 181 (emend. e *Cheiomys*).
1811. *Chiromys* Illiger, Prodrom. Syst. Mamm., Av. p. 75 (emend. e *Cheiomys*).
1816. *Psilodactylus* Oken, Lehrb. Naturg. 3. Theil, Zool. 2. Abth. p. xi.
Type by monotypy and tautonymy (*Lemur psilodactylus* Shaw) *Sciurus madagascariensis* Gmelin.
1839. *Myspithhecus* Blainville, Ostéogr. Mamm. i. fasc. iii. p. 33 (nom. altern. pro *Cheiomys*=*Daubentonia*).
1846. *Myslemur* Blainville, Dict. Univ. H. N. viii. p. 559 (nom. nov. pro *Myspithhecus*).

DAUBENTONIA MADAGASCARIENSIS Gmelin §.

Syn. *psilodactylus* Shaw §||.

I have not seen any specimen with definite locality. The range of this animal appears to include the whole forested portion of Madagascar in the east, and apparently also in the north-west.

* Schlegel, Mus. H. N. Pays-Bas, vii. p. 299 (1876).

† Lorenz, loc. cit. p. 452.

‡ Loc. cit. p. 2.

§ Ex *Aye-aye* Sonnerat, Voy. Ind. or. Chine, ii. p. 1, pl. (1782).

|| *Tarsius Daubentonii* G. Cuvier & E. Geoffroy, Mag. Encyclop. (2) i. p. 49 (1796), ex *Le Tarsier*, Daubenton, in Buffon, Hist. Nat. xiii. p. 87, pl. ix. (1765); cited by Elliot under this species as *Tarsius tarsier* Erxleben.

While this paper was in print I received from Dr. G. Grandidier his description of *Cheiromys madagascariensis laniger* *. Without a re-examination of the specimen, the locality of which is not given, no final conclusion can be arrived at. But there is some suspicion that it is only a specimen in moulting pelage.

* Bull. Ac. Malgache, i. p. 106, pl. (1930).

21. Report on Freshwater Nematoda: Mr. Omer-Cooper's Investigation of the Abyssinian Freshwaters (Hugh Scott Expedition). By I. FILIPJEV (Institute of Plant Protection, Leningrad, U.S.S.R.).

[Received November 17, 1930. Read April 14, 1931.]

(Text-figures 1-6.)

The freshwater and terrestrial Nematoda of tropical countries have been very little investigated. This is very true of Tropical Africa. The first contribution to our knowledge of that fauna comes from Daday (1910). It deals with the material brought by Dr. F. Fülleborn from Tanganyika Territory (formerly German East Africa). Eighteen species of Nematoda, in all, are mentioned; nine are described as new, the others are considered as representatives of species already known from Europe. Many of the species are very poorly described, as are most of the species described by this author, and hardly recognizable without reference to typical or at least topotypical material. One of them was found in the present material, and is dealt with in detail below.

Micoletzky (1915) described another chance collection from South Africa, chiefly from the Zambesi River. He deals with thirteen species, five new. His descriptions are quite good, but there is a cardinal defect in all his papers that was gradually disappearing during the later years of his life. He deals with the Nematode species as a very broad congregation of related but quite different species. The climax in this direction was reached in his large book on the soil Nematoda (1922), which in many instances confuses instead of clearing the matter; because although one can be quite sure of the described and figured species, the right determination of species only named and measured (the supposed old ones) is always subject to doubt. I attempted to criticize some of his determinations when I had the material to do so.

A third contribution came from Steiner (1916), who studied Michaelsen's materials brought from South-west Africa. There are only five freshwater species in his list. A little note of the same author (1916 *a*) deals with three Nematode species found in Comoro Islands.

The writer (1929) described two new species of *Actinolaimus* from the Transvaal, S. Africa, brought by Dr. and Mrs. G. E. Hutchinson.

The present paper deals with ten species (five among them considered as new) from Abyssinia, collected there by Mr. Joseph Omer-Cooper. The writer is sincerely thankful to Mr. J. Omer-Cooper, who took the trouble not only of collecting but also of sorting the material.

Besides this, several species are known from Egypt, Tunisia, Algeria, and Libya, *i. e.*, from Palaearctic Africa; they are not considered here.

Together we have the following list of free-living Nematoda, which is arranged in systematic order;—

ENOPLATA

TRILOBIDÆ*.

- Tripyla glomerans* Bast (*Tr. papillata* Büt.). Abyssinia (*Fil.*). A widely spread European species.
- Trilobus pellucidus* Bast. Abyssinia (*Fil.*); Kilimanjaro (*Dad.*); S.W. Africa (*St.*). Widely spread in Europe, chiefly a freshwater species.
- Tr. graciloides* Daday. Abyssinia (*Fil.*); Rikwa Lake, Nyassa Lake (*Dad.*); Zambesi (*Mic.*), as *Tr. gracilis* (Bast). Known from Africa only.
- Mononchus tenuis* Daday. Nyassa Lake; a doubtful species, not a *Mononchus*, fide Cobb (1917) and Micoletzky (1922); possibly a *Prismatolaimus*.
- M. macrostoma* Bast. A pond near the Nyassa Lake (*Dad.*). A widely spread European terrestrial and freshwater species, described also from North and South America; probably cosmopolitan.
- M. gerlachei* de Man. Comoro Islands (*St.*). Described from the Antarctic.
- M. sp.*, *Mic.* Zambesi (*Mic.*).

DORYLAIMIDÆ.

- Alaimus primitivus* de Man. Zambesi (*Mic.*). Described from Europe, terrestrial and freshwater; mentioned by Micoletzky (1925) from S. America also.
- Dorylaimus stagnalis* Duj. Zambesi (*Mic.*); Abyssinia (*Fil.*). A cosmopolitan form known from Europe, Asia, S. America (?).
- D. merogaster* Steiner. S.W. Africa (*Steiner*). After Micoletzky (1922); a variety of the foregoing species.
- D. pachydermis* Dad. Kilimanjaro (*Dad.*). A somewhat doubtful species.
- Dorylaimus bastiani* Bütschli. Kilimanjaro (*Dad.*); Zambesi (*Mic.*). Probably a cosmopolitan species or at least inhabiting all parts of the Old World; widely spread in Europe, Asia, Pamir, Java, S.W. Australia, Kerguelen Isle.
- D. flavomaculatus* Linst. Zambesi (*Mic.*); Abyssinia (*Fil.*). Widely spread in Europe; a freshwater species.
- D. filiformis* Bast. Lake Jippe (*Dad.*). A freshwater species, found in Europe, Asia, Egypt, N. Guinea.
- D. limnophilus* de Man. Bura swamp (*Dad.*). A terrestrial and pond species, not very common, but widely spread in Europe.
- D. elegans* de Man. Kilimanjaro (*Dad.*). Found elsewhere in Holland only.
- D. africanus* Dad. Kilimanjaro (*Dad.*).
- D. parvus* de Man. Comoro Is. (*Steiner*). Originally described from soil in Holland and Germany.
- Chrysonema abyssinica* Fil. Abyssinia (*Fil.*).
- Chr. thorni* Fil. Abyssinia (*Fil.*).
- Actinolaimus omer-cooperi* Fil. Abyssinia (*Fil.*).
- A. hutchinsoni* Fil. Transvaal (*Fil.*).
- A. africanus* Fil. Transvaal (*Fil.*).
- A. labyrinthostoma* Cobb. Comores (*Steiner*). Cobb (1893) described the species from Fiji; Steiner's data are possibly based on an undescribed species.

* The systematic order is that accepted in my paper on the general systematics of the Nematoda (Proceedings of the U.S. National Museum, January 1929).

- A. macrolaimus* de Man. Found everywhere in Tanganyika Territory by Daday. It is probable that several species are confounded together under this name. Micoletzky cites it from Zambesi.
- A. michaelsoni* Steiner. S.W. Africa. Belongs possibly to a new genus, intermediary between *Chrysonema* and *Actinolaimus*.

CHROMADORATA.

PLECTIDÆ.

- Plectus africanus* Daday. Kilimanjaro.
- Pl. sambesii* Micoletzky. Zambesi.
- ? *Cephalobus brachyuris* Dad. From the Jippe Lake, seems to be a *Plectus*.

CAMACOLAIMIDÆ.

- Cephalobus uncatus* Dad. From the Jippe Lake, and is possibly an *Aphanolaimus*.

CHROMADORIDÆ.

- Achromadora monohystera* (Mic.) (= *Chromadora monohystera* Mic.). Zambesi.

MONHYSTERATA.

MONHYSTERIDÆ.

- Monhystera vulgaris* de Man. Nyassa and river near by (Dad.); Zambesi, Pt. Elizabeth, Cape Colony (Mic.). Seems to be too small for this species as compared with European examples. Daday's data are too brief to be sure of the determination. *M. vulgaris* is known from Europe, Tunisia, and Peru; a freshwater species.
- M. similis* Büt. Nyassa (Dad.); Zambesi (Mic.). A freshwater species, Europe and Mongolia.
- M. paludicola* de Man. S.W. Africa (Steiner). A very common European freshwater species.
- M. parvella* Fil. Abyssinia (Fil.).
- M. fuelleborni* Dad. Nyassa. The species is very doubtful because of the meagre description.
- Theristus bothriolaima* (Steiner); *Monhystera bothriolaima* St. S.W. Africa.
- Cephalobus palustris* Daday. From the Bura swamp, E. Africa; seems to be a *Cylindrolaimus*.

ANGUILLULATA.

TYLENCHIDÆ.

- Diplogasteroides africanus* Mic. Zambesi.
- Tylenchorhynchus africanus* Mic. (*Tylenchus africanus* Mic.). Zambesi.
- Aphelenchus abyssinicus* Fil. Abyssinia.

One can see from this compendium that forty species only have been recorded from material brought from Tropical Africa, i. e., the Etnopian zoogeographical region, a small part only of the species really occurring there:—

Fifteen of them are known from Europe and elsewhere;

Two are known from the Antarctic and Australia ;

Twenty-three are known from Africa only.

Comparing the last group with the foregoing, we perceive a higher percentage of endemic forms than that given by former authors, namely, 57 per cent. The percentage seems to be less in the Trilobidæ and Dorylaimidæ than in the other groups treated.

The writer is even of the opinion that after a thorough revision of the material serving as base to the papers of Daday and Micoletzky the percentage of endemic species will be higher than the present one. It is quite certain that the fauna of any separate zoogeographical region is chiefly composed of endemic species, the number of cosmopolitan ones being only a comparatively small fraction of the whole. Contrary views on this subject are based, firstly, on the scarcity of the collections brought from tropical countries, and, secondly, on the very large percentage of freshwater pond species collected, among which cosmopolitan species are more numerous than in any other ecological group. A similar picture is presented by other groups of microscopical animals.

The same is probably true of the saprozoic species living both in soil and fresh water to judge from the paper of Rahm (1929) treating of Nematodes found on the roots of cultivated plants in Brazil. The large number of new forms described both from Europe and tropical countries of late years is a result of our poor knowledge of this particular group.

Very little is known about the species from flowing water, from the bottom of lakes, or from springs, not to mention the non-saprozoic soil fauna ; one may suppose that nearly all the species of this fauna brought to light would be new to science.

The following table gives the distribution of the Abyssinian species in the different waters in which collections were made. For general description of the waters and localities see Omer-Cooper (1930).

| Species. | Watersheds : localities. | | | | | | | | | Total no. of specimens. |
|---|--------------------------|--------------|------------|----------------|-------------------|--------------|---------------|--------------|----------------------------|-------------------------|
| | Blue Nile. | Hawash. | | | | | | Rift Valley. | | |
| | Wouramboulchi. | Mt. Zequala. | Djem Djem. | Hora Bishoftu. | Hora Bishoftu II. | Hora Horeso. | Hora Harsadi. | Hora Shala. | Water-hole N. of R. Makki. | |
| 1. <i>Tripyla glomerans</i> Bast. | 1 | 36 | — | — | — | — | — | — | — | 36 |
| 2. <i>Trilobius graciloides</i> Daday | 3 | — | — | 7 | 22 | 4 | 1 | — | 11 | 48 |
| 3. <i>Tr. pellucidus</i> Bast. | 1 | — | — | — | — | — | — | — | — | 1 |
| 4. <i>Dorylaimus flavomaculatus</i> Linst. | — | — | 1 | — | — | — | — | 12 | — | 13 |
| 5. <i>D. stagnalis</i> Duj. | — | 1 | — | — | — | — | — | — | — | 1 |
| 6. <i>Chrysonema abyssinica</i> , sp. n. | — | 1 | — | — | — | — | — | — | — | 1 |
| 7. <i>Chr. thorni</i> , sp. n. | — | — | — | 1 | — | — | — | — | — | 1 |
| 8. <i>Actinolaimus omer-cooperi</i> , sp. n. | 3 | 1 | — | 8 | 1 | — | 2 | — | — | 15 |
| 9. <i>Monhystera parvella</i> , sp. n. | — | — | — | — | — | — | — | 13 | — | 13 |
| 10. <i>Aphelenchus abyssinicus</i> , sp. n. | — | — | — | — | 1 | — | — | — | — | 1 |
| Total | 7 | 39 | 1 | 16 | 24 | 4 | 3 | 25 | 11 | 130 |

Note.—The letters before the formulæ in the descriptions below give the first letters of the collecting place of the individual measured, to compare with the localities given at the end of each description.

The formulæ are the modified Cobb's formulæ (see Filipjev (1927)), giving *above* the distances from the anterior extremity to (1) the bottom of mouth-capsule, (2) the middle of the nerve-ring, (3) the end of the œsophagus, (4) the vulva, (5) the anus; *below*, the body diameters (1) at the head-setæ, others at same places as the corresponding lengths; in the male (4) the greatest diameter is given instead of the vulvar one.

TRIPYLA GLOMERANS Bastian, 1865.

Bastian 1865, p. 115, t. ix, ff. 16–17; sec. Micoletzky, 22.

Tripyla papillata Bütschli, 1873; Filipjev, 1929, p. 685.

| | | | | | | | | | | | | | |
|----|----|---|-----|-----|------|-------|------|---|------|-------|----|------|-------|
| ♂. | — | 240 | 410 | — | 1580 | 2020; | ♂. | — | 240 | 380 | — | 1910 | 2440; |
| | 36 | 66 | 68 | 69 | 61 | | | 36 | 66 | 66 | 66 | 60 | |
| | | α 31, β 4.9, γ 4.6; | | | | | | α 37, β 6.4, γ 4.6. | | | | | |
| ♀. | — | 240 | 390 | 855 | 1050 | 1170 | 1310 | 1460 | 1855 | 2290; | | | |
| | 37 | 61 | 68 | | | 72 | | | 54 | | | | |
| | | α 32, β 5.9, γ 5.3. | | | | | | | | | | | |
| ♀. | — | 265 | 435 | 910 | 1060 | 1280 | 1500 | 1680 | 2030 | 2500. | | | |
| | 40 | 66 | 66 | | | 78 | | | 52 | | | | |

The tail is long, 7–9 anal diameters; 0.2 wide at the end in the male, 0.3 in the female. The œsophagus from 28–30 widens to 37–40 μ behind. Rectum 50 μ long. The vagina 55 μ , the spicula 70 μ ; no papillæ were seen before the anus. Quite typical specimens.

Material.—Mt. Zaquala, 22. x. 26, 5 ♂, 11 ♀, 20 juv.

A widely spread species, chiefly a freshwater one, known throughout Europe, from the Arctic (N. Zemlja, Greenland), Faroes to Switzerland, Hungary, Boucovina, Oka and Volga Rivers near Saratov. It is very probable that the lack of data from southern Europe is due only to the absence of investigators. In the Tropics this species seems to be absent unless *Tr. crassicauda* Daday (1899), found in a sago-marsh in New Guinea should prove to be synonymous with this species as Micoletzky thinks (1925). It was absent in the collections from Africa previously described.

TRILOBUS GRACILOIDES Daday (1910). (Text-fig. 1, a–d.)

Daday, 1910, 46, t. ii, ff. 13–16.

Trilobus gracilis Micoletzky, 1915.

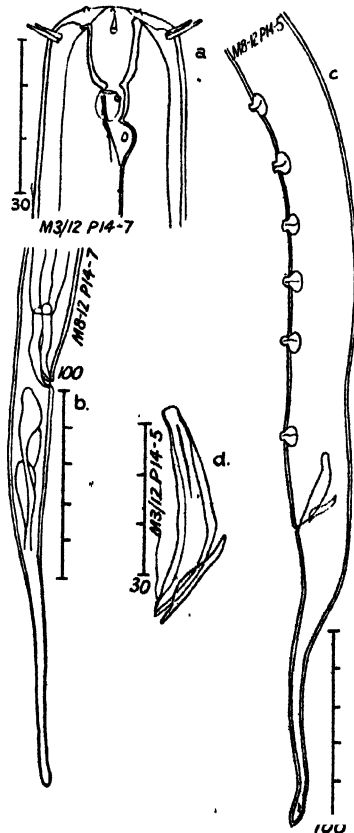
| | | | | | | | | | | | | | |
|----------|--|-----|-----|-----|------|-------|-----|-----|------|-------|----|------|-------|
| ♂. (HB2) | 23 | 115 | 280 | — | 1365 | 1530; | ♂. | 23 | 115 | 280 | — | 1365 | 1530; |
| | 24 | 36 | 43 | 44 | 31 | | | 24 | 36 | 40 | 44 | 31 | |
| ♂. (HB2) | 23 | 110 | 275 | — | 1345 | 1600; | | | | | | | |
| | 24 | 35 | 42 | 44 | 31 | | | | | | | | |
| | ♂. α 34 (33–35), β 5.2 (4.7–5.5), γ 9.5 (9.3–9.7). | | | | | | | | | | | | |
| ♀. (HB) | 24 | 110 | 275 | 440 | 585 | 665 | 730 | 870 | 1270 | 1460; | | | |
| | 29 | 41 | 45 | | | 58 | | | 28 | | | | |
| ♀. (HB) | 26 | 110 | 300 | 490 | 640 | 725 | 810 | 955 | 1390 | 1610; | | | |
| | 32 | 42 | 50 | | | 60 | | | 26 | | | | |

| | | | | | | | | | | |
|---------|----|-----|-----|-----|-----|-----|-----|------|------|-------|
| ♀. (HB) | 26 | 115 | 315 | 440 | 630 | 730 | 830 | 1045 | 1540 | 1790; |
| | 29 | 46 | 54 | | | 60 | | | 36 | |
| ♀. (MR) | 24 | 115 | 325 | 615 | 710 | 765 | 850 | 965 | 1455 | 1670; |
| | 23 | 32 | 40 | | | 46 | | | 26 | |

♀. α 30 (25-37), β 5.4 (5.1-5.7); γ 7.4 (6.8-8.2).

Body tapering to both ends. Tail elongate, with the posterior half to six-tenths forming a flagellum, tapering much more slowly at the basal part; the end is somewhat clavate. The diameter of the clavate part is $4\frac{1}{2}$ -6 μ , i. e., 0.16 an. dm., that of the thinnest part 4 μ , i. e., 0.10-0.12 an. dm., the

Text-figure 1.

*Trilobus graciloides* Daday.

a. Head of the female. b. Tail of the female. c. Tail of the male. d. Spicules.

length of the tail in the female is 5.2-8.5 (7.1) an. dm., in the male 4.3-5.3 (4.9); this difference is present not only because of the greater anal body diameter in male, but also because of a greater tail-length in the female. The cuticle is smooth, nearly $1\frac{1}{2}$ μ thick. The epidermal crystals seem to be absent.

The head is continuous, with six low labial papillae and ten short cephalic setae, of which the longer ones measure 5-6 μ , i. e., $\frac{1}{3}$ - $\frac{1}{4}$ of the cephalic body-width. The amphids are of the regular pocket-like type, comparatively small, 5 μ wide, nearly one-sixth of the corresponding body-diameter, the opening

is smaller; they are situated at 10–12 μ from in front, somewhat less than half of the width of the head.

The buccal capsule is 10–12 μ long, with moderately thick walls, succeeded by the two postbuccal pockets well separated but immediately following one another; each one bears one tooth inside. The oesophagus is large, uniform throughout its length, quite a little expanded to its hind end. The cardia, the intestine, and rectum have no peculiarities.

The ovaria are short with the oblique ovules disposed in single file; there are no more than one or two ripe ova in each branch of the uterus; they measure 48–62 \times 26–30 μ . The vagina measures 32 μ ; it has a refractive but thin lining. In some individuals it is much shorter, which is in correlation with the distended uterus.

The testes are paired. The spicules are thick-walled, moderately bent, with a feeble ridge near the base; the gubernacle is flat, surrounding their ends. The length of the spicules is very constant, 42–44 μ , i. e., 1.2–1.3 anal body dm., that of the gubernacle 22 μ , i. e., half of the length of the spicula. There are six strongly developed anal papillae 11–13 μ long and as much wide, the anterior and posterior papillae are generally at a greater distance from each other than are the intermediate papillae; but this is very variable, and probably changes in each individual after the last moult. The measuring of these distances in three individuals gave, respectively, the following data (by measuring from before to the anus): (1) 35, 25, 25, 22, 30, 45; (2) 33, 32, 31, 33, 48, 48; (3) 34, 26, 38, 37, 50, 35.

Localities.—N. of Makki River, water-hole, 28. xi., 6 ♀, 5 juv.; Wouramboulchi, 2–7. x., 3 ♀; Hora Horeso, 1. xii., 3 ♀, 1 juv.; Hora Horsadi, Addas, 2. xii., 1 juv.; Hora Bishoftu 2. xii., 1 ♂, 2 ♀, 4 juv.; Hora Bishoftu, 11. 3. xii., 6 ♂, 15 ♀, 7 juv.

Described by Daday (1910) from Rikwa and Nyassa Lakes, E. Africa; the measurements given by Micoletzky (1915) for the material from the Zambesi River, treated by him as *Tr. gracilis* Bast., leads us to suppose that at least a part of his material belongs to Daday's species.

The species comes exceedingly near to *Tr. helveticus* Hofmänner (1913) (see Filipjev, 1928), but the tail is typically longer and clavate, a character absent in the latter; further, Hofmänner mentions nine preanal male papillae (other authors did not find males); here there are only six present. Further material would prove or disprove the identity of both. Should they prove synonymous Daday's name will have priority.

TRILOBUS PELLUCIDUS Bastian, 1865.

Filipjev, 1928, p. 96.

| | | | | | | | | | | |
|----|----|-----|-----|-----|-----|------|------|------|------|-------|
| | 17 | 135 | 390 | 655 | 900 | 1010 | 1170 | 1485 | 2080 | |
| ♀. | 31 | 48 | 55 | | | 68 | | | 35 | 2330; |

α 34, β 6.7, γ 9.3, V. 43.

Very similar to the foregoing in shape and general proportions, but larger. Tail 7 an. dm., 5 μ , i. e., 0.14 wide at the end. Cuticle thin, 1 μ , cephalic setae longer, 7–9 μ . Amphide of same form and in the same position, nearly 8 μ wide. The buccal capsule proper 14 μ long, the back chambers somewhat more posterior in position. Oesophagus 27–37 μ wide, cardia 22 μ long, 35 wide. Ovaria long, uterus double, with two or four ova in the branches. The eggs are 28–32 μ long and equally wide.

I have some doubt in attributing this individual to the above species; the lack of a male does not allow of a definite decision.

One female, Wouramboulchi, Serpent Lake, 5. x.

DORYLAIMUS FLAVOMACULATUS Linstow, 1877.Filipjev, 1928, p. 104, t. ii. f. 10, *a-b*.

| | | | | | | | | | | | | | |
|--|----|-----|-----|-----|------|-------|---------|----|-----|-----|-----|------|-------|
| ♂. (DD) | 13 | 110 | 255 | — | 960 | 980; | ♂. (HS) | 14 | 100 | 285 | — | 1140 | 1165; |
| | 11 | 37 | 43 | 45 | 24 | | | 13 | 33 | 38 | 42 | 29 | |
| ♂. (HS) | 14 | 100 | 255 | — | 1445 | 1470; | ♂. (HS) | — | 100 | 250 | — | 1368 | 1390; |
| | 13 | 33 | 35 | 44 | 24 | | | 13 | 33 | 37 | 44 | 23 | |
| ♀. (HS) | 15 | 115 | 270 | 705 | 1700 | 1810; | ♀. (HS) | 14 | 105 | 255 | 695 | 1595 | 1720; |
| | 13 | 33 | 40 | 48 | 28 | | | 13 | 31 | 35 | 44 | 25 | |
| ♀. (HS) | 14 | 105 | 265 | 750 | 1700 | 1850; | ♀. (HS) | — | 100 | 260 | 600 | 1460 | 1570; |
| | 14 | 31 | 37 | 42 | 19 | | | 13 | 37 | 47 | 47 | 29 | |
| ♀. α 33-44 (39), β 6.0-7.0 (6.6), γ 12-17 (15), V. 38-41 (40); | | | | | | | | | | | | | |
| ♂. α 22-33 (29), β 3.5-5.6 (4.8), γ 46-64 (52). | | | | | | | | | | | | | |

As compared with the individuals from the Oka River studied by me (1928) the Abyssinian specimens are smaller and absolutely shorter; the comparative length (α) is, however, the same. The spear is a little shorter.

Cuticle 1.5μ . The oesophagus is $7-9 \mu$ wide in the fore and 22μ in the hind part. The uterus is $80-190 \mu$ long, the ovaria $170-320 \mu$, not more than two ova in each branch of the uterus, the ova measure $65-70 \times 25-30 \mu$. The vagina 30μ ; the prærectum of the female $120-140 \mu$; the spicula measured $37-46 \mu$; the papillæ are 18-22 in number; the testis is double.

Localities.—Djem-Djem Forest, pond no. 2, 25. ix., 1 ♂: Hora Shala, small pond, 21. xi., 3 ♂, 4 ♀, 5 juv.

Well known throughout most parts of Europe, where collections have been made: Sweden, Denmark, Germany, Poland, Bucovina, Russia. Characteristic of fresh water or very damp soil. Found also in S. Africa (Zambesi) by Micoletzky (1915).

DORYLAIMUS STAGNALIS Dujardin, 1845.Filipjev, 1928, p. 100, t. ii. f. 8, *a-f*; 1929, t. vi. f. 5.

| | | | | | | | | | | |
|--|----|-----|-----|------|------|------|------|------|------|-------|
| ♀. | 42 | 180 | 670 | 1020 | 1320 | 1660 | 1950 | 2330 | 3550 | 3900; |
| | 20 | 57 | 85 | | | 86 | | | 32 | |
| α 45, β 5.8, γ 11, V 43. | | | | | | | | | | |

Tail 11 an. dm., long and 0.12 wide at the end. Cuticle $3-4 \mu$, oesophagus $18-20$ and 55μ , the distance from the head to the beginning of the musculature 80 , rectum 75 , prærectum 160μ , ova $101 \times 37 \mu$; ovejector present, oviduct coiled, with spermatozoa inside, vagina 31μ .

Locality.—Mt. Zaquala, 22. x., 1 ♀.

A freshwater species, accidentally brackish water, rarely terrestrial. Found in every part of Europe, in Asia from Siberia to China and Ceylon, S. and E. Africa (Micoletzky (1915), Daday (1910), and S. America (Daday (1905)).

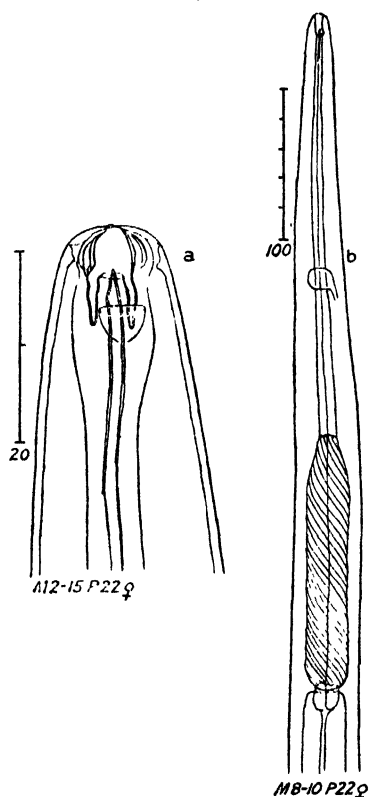
It is very difficult to decide if all the large material studied by different authors and referred to *D. stagnalis* really belongs to one species. Steiner (1919) was of the opinion that it is a mixture of a large number of species; this opinion seems to be consolidated by the large amount of variation found by several recent authors in this "species", several varieties having been described by them. Nevertheless the absence of definite characters makes it impossible to distinguish with certainty the species which may be present. A monographic study of such material would be very welcome.

Genus *CHRYSONEMA* Thorne, 1929.

This genus was established for an aberrant *Dorylaimoid* species found in Utah, U.S.A., on insects. The genus is poorly discussed by the author, but may be regarded as valid. It takes an intermediary position between *Dorylaimus* and *Actinolaimus*, having a very wide vestibulum as in the last, but devoid of any guiding onchi as well as of strongly chitinated walls.

Actinolaimus tobleri Micoletzky (1925), *Dorylaimus vestibulifer* Micoletzky (1922), *Chrysonema aureum* Thorne (1929) are probable members of this genus as well as the two new ones described below. *Actinolaimus michaelsoni* Steiner (1916) and *Dorylaimus cyatholaimus* Daday (1905) seem to possess guiding onchi in the vestibulum, and cannot therefore be included in this genus.

Text-figure 2.

*Chrysonema abyssinica*, sp. n.

a. Esophageal part of the female. b. The head of the same.

CHRYSONEMA ABYSSINICA, sp. n. (Text-fig. 2, a, b.)

| | | | | | | | | | | |
|----|----|-----|-----|------|------|------|------|------|------|-------|
| ♀. | 13 | 180 | 440 | 1210 | 1340 | 1710 | 2030 | 2210 | 4910 | |
| | 13 | 34 | 50 | | | 52 | | | 33 | 5400; |

α 104, β 12·3, γ 11, C. 15.

Body filiform, tail very long, filiform with an acute end. Cuticle 2 μ.
Head devoid of spreading papillæ, with a large pocket-shaped amphide

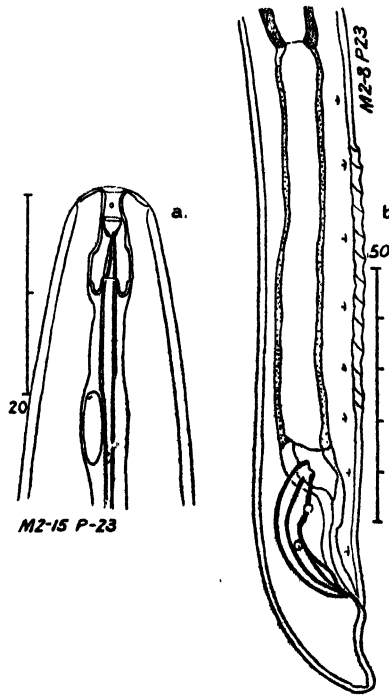
situated $8\ \mu$ from in front, measuring $5\ \mu$, somewhat less than a third of the corresponding body diameter.

The vestibulum is wide, having a very narrow opening in front; the walls of the fore part seem to be chitinized. The spear is $13\ \mu$ long, narrow, and truncate obliquely at the end. The oesophagus is $10\ \mu$ wide in front, less in the non-muscular part, then widens very regularly to $11\text{--}12\ \mu$, then rather suddenly to $26\ \mu$. This basal widening is enveloped by some oblique fibres, probably muscular. The prærectum is short, $80\ \mu$, the rectum $32\ \mu$.

The female genitalia were not yet quite developed, but showed a well-developed uterus and a strongly cutinized vagina $35\ \mu$ deep.

One female, Mt. Zaquala, 22. x.

Text-figure 3.



Chrysonema thorni, sp. n.

a. The head of the male. b. The tail of the same.

CHRYSONEMA THORNI, sp. n. (Text-fig. 3, a, b.)

| | | | | | | |
|----|----|-----|-----|----|------|-------|
| ♂. | 12 | 105 | 280 | — | 1015 | |
| | 9 | 23 | 26 | 27 | 21 | 1040; |

$\alpha\ 39, \beta\ 3.7, \gamma\ 42, \text{O. } 1.2.$

Body filiform, tail short, conical, rounded at the end. Cuticle smooth, $1\text{--}1\frac{1}{4}\ \mu$ thick.

Head rounded, without spreading papillæ, with a very small amphide $2\ \mu$ wide, situated just behind the lateral head-papilla.

Vestibulum wide, the walls not chitinized. The spear is $12\ \mu$ long,

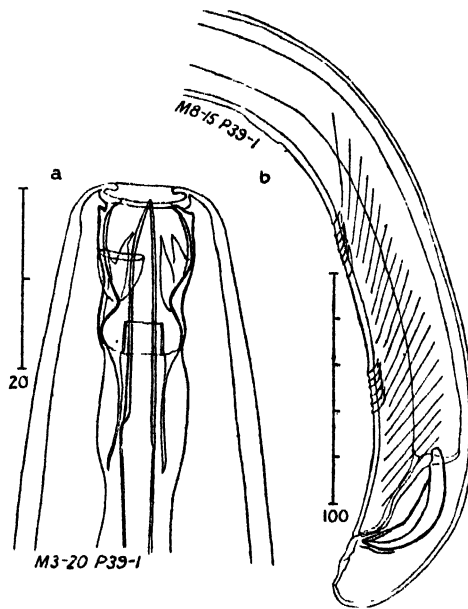
1½ times longer than the length of the vestibulum to its guiding ring. The oesophagus from 6-7 μ in front, widens to 15 μ at its hind end. The prærectum is very long, 130 μ , the rectum 35 μ .

The testes are double, the sperms are very large, $10 \times 3 \mu$, the spiculæ measure 35 μ , 1.7 an. dm. There are 13 ventro-medial papillæ, disposed in one single row: they are followed by 8 pairs of small submedian papillæ and by two rather large lateral papillæ disposed against the spiculæ.

Locality.—Hora Bishoftu, 2. xii., 1.

Dedicated to Mr. Gerald Thorne of Salt Lake City, Utah, U.S.A., the author of the genus, as a tribute to the valuable contributions to a knowledge of the Nematoda made by him.

Text-figure 4.



Actinolaimus omer-cooperi, sp. n.

a. Head of the male. b. Tail of the same.

ACTINOLAIMUS OMER-COOPERI, sp. n. (Text-fig. 4, a, b.)

| | | | | | | | | | | | | | |
|--------|----|-----|-----|------|------|-------|--------|----|-----|-----|------|------|-------|
| ♂.(HB) | 26 | 160 | 535 | — | 2525 | 2550; | ♂.(HB) | 26 | 175 | 570 | — | 2815 | 2840; |
| | 20 | 42 | 52 | 52 | 31 | | | 20 | 40 | 45 | 45 | 33 | |
| ♀.(Z) | 33 | 220 | 830 | 1650 | 3530 | 3820; | ♀.(HH) | 29 | 165 | 570 | 1420 | 3010 | 3260; |
| | 22 | 51 | 81 | 88 | 36 | | | 20 | 43 | 52 | 59 | 31 | |
| ♀.(HH) | 25 | 160 | 550 | 1240 | 2900 | 3120; | ♀.(HB) | 28 | 165 | 530 | 1130 | 2710 | 2900; |
| | 20 | 42 | 53 | 55 | 26 | | | 20 | 40 | 48 | 55 | 27 | |

♂. α 50-62, β 4.8-5.0, γ 102-114, C. 0.8.

♀. α 43-57, β 4.6-5.7, γ 10-15.3, V. 39-44, C. 7.0-8.5.

Body filiform, tail in the female 190-290 μ long, with a filiform end; tail of the male short, rounded. Cuticle smooth, $2-2\frac{1}{2} \mu$.

Head continuous, without separated lips, bearing small papillæ and an amphide $6\ \mu$ wide, $2/7$ of the corresponding diameter. The vestibulum has thick walls; its lumen seems to be prolonged in narrow folds at a distance somewhat less than the length of the vestibulum proper. The guiding onchi are directed forward and are conical in shape. The spear is slender, with nearly parallel walls except in its fore part. The œsophagus is $15\text{--}26\ \mu$ wide in its fore part and $29\text{--}37\ \mu$ in the hind part. The cardia is $20\ \mu$ long, the rectum $40\ \mu$, the prærectum is of variable length, $220\text{--}310\ \mu$.

The testes are double, the spicula not very strongly cutinized, $48\text{--}55\ \mu$ long. There exist three groups of elevations in front of the anus, at subequal distances from each other. Both the posterior bear very marked groups of papillæ 6–7 each; the anterior is apparently devoid of papillæ, possessing a cuticular plate only. It corresponds evidently to the "Kopulationshöcker" described in several *Dorylaimus*. A ventral papilla is present in the tail.

The ovaria are double, the anterior is long, $350\ \mu$ ($220\text{--}460$), but always shorter than the posterior, $540\ \mu$ ($450\text{--}620$). The hind uterus is also longer than the fore one, viz., 350 ($270\text{--}430$) and 270 ($230\text{--}300$) μ . The ova in the *Zaquala* specimen measured $57\text{--}72 \times 31\text{--}37$; in others $86\text{--}92 \times 31\text{--}32\ \mu$; the vagina $16\text{--}24\ \mu$.

Localities.—Wouramboulchi, 2–7. x., 2 ♀, 1 juv.; *Zaquala*, 22. x., 1 ♀; Hora Bishoftu, 2. xii., 2 ♂, 3 ♀, 3 juv.; Hora Bishoftu II., 3. xii., 1 ♀; Hora Harsadi, Addas, 2. xii., 2 ♀.

This species belongs to a group of typical *Actinolaimi* with sharply forward-pointing vestibular onchi, to which *A. africanus* Filipjev (1929), *A. hutchinsoni* Filipjev (1929), and *A. propinquus* Cobb (1915) seem to be the only members. All three seem to have the spear short, as in the present species.

MONHYSTERA PARVELLA, sp. n. (Text-fig. 5, a–c).

| | | | | | | | | | | | | | | | | |
|----|---|----|----|---|-----|-----|------|--|----|----|----|---|-----|-----|------|--|
| ♀. | 9 | 55 | 85 | p | 210 | 240 | 345 | | 10 | 50 | 75 | p | 180 | 215 | 325 | |
| | 7 | 12 | 14 | | 20 | 13 | 450; | | 9 | 15 | 18 | | 18 | 13 | 430; | |

♀ : α 22–24, β 5.3–5.7, γ 4.1–4.2, V. 50–53.

The body is moderately short, narrowing evidently at both ends. The cuticle is very thin, nearly $1\ \mu$, apparently devoid of striations. The tail is long, $9\text{--}10\ \mu$ longer than the anal body diameter, narrowing very uniformly to the filiform end, which measures $\frac{1}{4}$ of its total length. There is a long excretory pore on the end of the tail; the latter is $2\ \mu$ wide, $\frac{1}{4}$ of the anal body diameter.

The head is rounded, bearing ten short cephalic setæ, the six longer $2\ \mu$, the four shorter ones $1\text{--}1\frac{1}{2}\ \mu$ long, the longer ones being somewhat shorter than $\frac{1}{4}$ of the head width. The amphide is circular, $3\ \mu$ wide, $\frac{1}{4}$ of the corresponding diameter.

The mouth-cavity is pyramidal, typical of the genus, the mouth-capsule proper measuring nearly $4 \times 2\ \mu$. The œsophagus from $5\text{--}7\ \mu$ before widens to $11\ \mu$ behind. The cardium is $11\ \mu$ long, the rectum $9\ \mu$.

The fore end of the ovarium was somewhat obscure; the length of the uterus is given in the formulæ. The ova measure $28 \times 18\ \mu$.

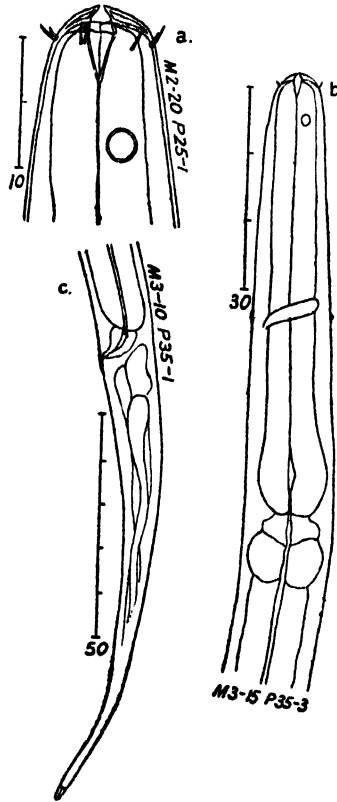
No males were found.

Locality.—Hora Shala, small pond, 6 ♀, 6 ♀ juv., 1 juv.

The species, in the comparative size and position of the amphide and the

form of the tail, comes very near to *M. kossensis* Paramonov (1929) and *M. vivipara* Allgen (1929). Both are of distinctly larger size than our species. The first one is an inhabitant of brackish waters, the second has a thicker tail and is viviparous.

Text-figure 5.

*Monhystera parvella*, sp. n.

a. Head of the female. b. (Esophageal part of the same. c. Tail of the same.

APHELENCHUS ABYSSINICUS, sp. n. (Text-fig. 6, a, b.)

| | | | | | | | | |
|----|----|-----|-----|------|-----|-----|------|-------|
| ♀. | 11 | 85* | 105 | (?)† | 600 | 710 | 1025 | 1100; |
| | 5 | | 18 | | | 36 | 10 | |

♂ 39, β 3.3 (13), γ 15, V. 66.

This species is very near to *A. parietinus* Bast., but differs in the stouter tail and the complete absence of the posterior branch of the uterus. Other nearly related species are much smaller.

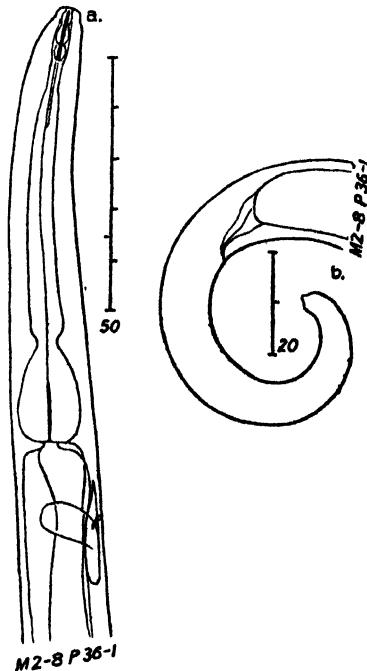
The cuticle is annulated, with the rings $0.7\ \mu$ wide. The oesophagus from $4\ \mu$ anteriorly widens to $8\ \mu$, then comes a column $6\ \mu$ wide with the middle bulbus

* The hind end of the middle bulbus.

† The end of the oesophageal glands.

12 μ wide. The spear is almost without any basal expansion; it is 11 μ long, i. e., 1/8 of the fore part of the oesophagus, succeeded by an expansion of the inner tube of the oesophagus, 12–13 μ long. No special radial muscles were seen

Text-figure 6.

*Aphelenchus abyssinicus*, sp. n.

a. Head end of the female. b. Tail of the same.

inside the bulbous, which is due possibly to the method of preservation. The eggs measured $78 \times 24 \mu$.

Locality.—Hera Bishoftu, 11. 3. xii., 1 ♀.

LITERATURE.

- ALLEN, C. (1926). Über einige freilebende Nematoden aus dem Wettersee. Arch. Hydrobiol. xvii. (4) pp. 714–729, figs. 1–4.
- BASTIAN, H. CH. (1865.) Monograph on the Anguillulidae, etc. Trans. Linn. Soc. xxv. pp. 73–184, t. 9–13.
- BÜTSCHLI, O. (1873.) Beiträge zur Kenntnis der freilebenden Nematoden. N. Acta. Acad. Leop.-Carol. xxxvi. (5) pp. 1–144, t. 17–27.
- COBB, M. V. (1915.) Some Freshwater Nematodes of the Douglas Lake Region of Michigan, U.S.A. Trans. Amer. Micr. Soc. xxiv. pp. 21–47.
- COBB, N. A. (1893.) Nematodes, mostly Australian and Fijian. Macleay Memor. Volume of Linn. Soc. N.S.W. pp. 252–304, t. 36–42.
- COBB, N. A. (1906.) Fungus Maladies of Sugar-cane. Rep. Exper. Sta. Hawaiian Sugar Planters' Association. Divis. Path. Phys. Bull. 8, t. f.
- COBB, N. A. (1917.) The Mononchs (*Mononchus* Bast. 1866), a Genus of Free-living Predatory Nematodes. Contrib. Sci. Nematology, vi. pp. 129–212, 70 figs. (Soil Science, 4, pp. 431–486.)

- COBB, N. A. (1918 a.) Filter-bed Nemas: Nematodes of the Slow Sand Filter-beds of American Cities, with Notes on Hermaphroditism and Parthenogenesis. *Contrib. Sci. Nematology*, vii. pp. 189-212, 9 figs.
- DADAY, E. (1899.) Mikroskopische Süßwasserthiere aus Deutsch-Neu-Guinea. *Termesz. Füz.* xxiv. pp. 1-56, t. 1-3.
- DADAY, E. (1905.) Untersuchungen über die Süßwasser-Mikrofauna Paraguays. *Zoologica*, xlv. pp. 1-375, 23 t.
- DADAY, E. (1910.) Untersuchungen über die Süßwasser-Mikrofauna Deutsch-Ostafrikas. *Zoologica*, lix. pp. 1-314, 18 t.
- DE MAN, J. G. (1921.) Nouvelles recherches sur les Nématodes libres terrioles de la Hollande. *Capita Zoologica*, i. (1) pp. 1-62, 14 t.
- DUJARDIN, F. (1845.) Histoire naturelle des helminthes ou vers intestinaux. Paris, pp. 16-654, 12 t.
- FILIPJEV, I. N. (1927.) Les Nématodes libres des mers septentrionales appartenant à la famille des Enoplids. *Arch. Naturg.* xli. a (6) pp. 1-216, t. 1-7, 1 fig.
- FILIPJEV, I. N. (1928.) Nématodes libres du fleuve Oka. *Arb. Biol. Oka-Station* 5 (2/3), pp. 81-113, t. 1-2.
- FILIPJEV, I. N. (1929.) Two new Species of *Actinolaimus* from South Africa. *Ann. & Mag. Nat. Hist.* (10) iv. pp. 433-439, 2 figs.
- FILIPJEV, I. N. (1929.) Les Nématodes libres de la baie de la Neva et de l'extrémité orientale du Golfe de Finlande. *Archiv Hydrobiol.* xx. pp. 637-699; xxi. pp. 1-64, 35 fig.
- HOFMÄNNER, B. (1913.) Contribution à l'étude de Nématodes libres du Lac Léman. *Rev. Suisse Zool.* xxi. (16) pp. 589-658, t. 15-16.
- LINSTOW, O. (1877.) *Helminthologica*. *Arch. Naturg.* xliii. pp. 1-18, t. 1.
- MICOLETZKY, H. (1915.) Süßwasser-Nematoden aus Süd-Afrika. *Denkschr. Kais. Akad. Wiss. Wien, Math. Naturw. Kl.* xcii. pp. 149-171, t. 1-4.
- MICOLETZKY, H. (1922.) Die freilebenden Erd-Nematoden mit besonderer Berücksichtigung der Steiermark und der Bukowina, etc. *Arch. Naturgesch.* lxxxvii. A (8, 9) pp. 1-650.
- MICOLETZKY, H. (1925 a.) Die freilebenden Süßwasser- und Moornematoden Danemarks hebet Anhang über Amobosporidien und andere Parasiten bei freilebenden Nematoden. *Mém. Ac. Roy. Sci. Lettres Danemark* (8) x. (2) pp. 55-310 (=1-256), t. 1-13.
- MICOLETZKY, H. (1925 b.) Zur Kenntnis tropischer, freilebenden Nematoden aus Surinam, Trinidad, und Ostafrika. *Zool. Anz.* lxiv. (1/2) pp. 1-28, figs. 1-10.
- OMER-COOPER, J. (1930.) Dr. Hugh Scott's Expedition to Abyssinia.—A Preliminary Investigation of the Freshwater Fauna of Abyssinia. *Proc. Zool. Soc.* 1930 (1), pp. 195-207, 2 maps, pls. i-viii.
- RAHM, G. (1929.) Nematodes parasitas e semi-parasitas de diversas plantas culturais do Brasil. *Arch. Inst. Biol. Defesa Agricola e Animal.* São Paulo, ii. pp. 67-136, t. 13-23.
- STEINER, G. (1916 a.) Nematoda. *Beitr. Kenntnis der Land- und Süßwasserfauna Deutsch. Südwestafrikas*, hrsg. v. W. Michaelsen, iv. pp. 377-411.
- STEINER, G. (1916 b.) Beiträge zur geographischen Verbreitung freilebender Nematoden. *Zool. Anz.* xlv. pp. 311-347, 11 figs.
- STEINER, G. (1919.) Die von A. Monard gesammelten Nematoden der Tiefenfauna des Neuenburgersees. *Bull. Soc. Neuchâteloise Sci. Nat.* xliii. pp. 142-240.
- THORNE, G. (1929.) Nematodes from the Summit of Long's Peak, Colorado. *Trans. Amer. Micr. Soc.* xlviii. pp. 181-195, 18 figs.

22. On the Anatomy of *Pseudocalyptomena* and the Occurrence of Broadbills (Eurylæmidæ) in Africa. By PERCY ROYCROFT LOWE, B.A., M.B. Cantab., F.Z.S.

[Received November 25, 1930: Read March 17, 1931.]

(Text-figures 1-11.)

In the 'Ibis' for 1909, pp. 690-691, Lord Rothschild described an entirely new genus and species of bird, *Pseudocalyptomena graueri*, which had been taken north of Lake Tanganyika in the bamboo-forest belt above the Russisi River at an elevation of 6000 feet. Nothing even remotely like this species or genus had ever been taken before in Africa, and only one specimen was acquired by the collector Mr. Rudolf Grauer. Several efforts were made by the writer to induce leaders of expeditions to Central Africa to make a thorough search for this bird, notably in the case of Mr. J. P. Chapin, of the New York Natural History Museum; but until 1929 no other example had been seen or collected. In that year an American expedition to Tanganyika, under the leadership of Messrs. Stirling Rockefeller and Charles Murphy, rediscovered the bird. The actual collector to find the first specimen was Mr. Alan Moses, who, after an exhaustive and fruitless search in the bamboo-forest belt, felt convinced that the bird no longer existed. Having given up the search, he one day climbed up to the canyon-seamed country above the bamboo-zone, which Mr. Chapin had always felt was in all probability the real home of this elusive species. Here he was sitting down to rest after a tiring climb when, happening to look up, he espied a bird in some bushes among the rocks above his head. There was only one bird it could possibly be, viz., *Pseudocalyptomena*; but I am informed that Mr. Alan Moses was so excited that he missed it. Fortunately others were discovered by the expedition in this its proper *terrain*, and a series collected, which included examples in spirit. I have been very generously allowed to dissect one of these latter and to describe the anatomical characters found. The notes below, resulting from my study of it, I venture to bring before the notice of this Society.

In his original description of this mysterious inhabitant of the volcanic peaks above the Lake of Kivu Lord Rothschild wrote:—"The position of this remarkable bird is uncertain; it is apparently a very aberrant flycatcher, in spite of its fully developed first primary, but at the first glance somewhat resembles a *Calyptomena* (Eurylæmidæ) on account of the shape of its bill, its short tail, and its green and blue colour, a combination of characters which is quite unique among African Passeres."

At the time when Lord Rothschild wrote the Eurylæmid family was regarded by ornithologists as being entirely confined to the Oriental Region (India (part), Malay Peninsula, Malay Archipelago, and Philippines). Moreover, as pointed out by Garrod (1876) and Forbes (1880), the Eurylæmids constitute a very distinct, and probably the lowest, division of the Passeres, from the rest of which they are separated by very definite structural features. In 1924, however, I published a paper in this Journal "On the Presence of Broadbills (Eurylæmidæ) in Africa," which proved, I think, quite beyond any question of doubt, that

the African genus *Smithornis*, previously regarded as belonging to the Flycatchers, must in reality be referred on anatomical grounds to the Eurylæmidæ. At the end of that paper (p. 290) I referred to Lord Rothschild's *Pseudocalyptomena*, and put the question, "Is this new Central African form actually a Broadbill and not merely reminiscent of one? When Lord Rothschild described this species . . . the presence of Broadbills had not even been suspected in Africa, and the last thing he would have thought was that his rare and highly interesting find might, in fact, very possibly be one."

One of the facts brought out in this paper is that in practically every anatomical detail, both external and internal, *Pseudocalyptomena graueri* is a Eurylæmid, and, incidentally, that in giving the genus this name Lord Rothschild showed his usual perspicuity in regard to the affinities of birds. Among the more interesting features in the anatomical make-up of *Pseudocalyptomena* is the presence of a vinculum between the tendons of the *flexor longus hallucis* and the *flexor digitorum profundus*, a feature which is characteristic of the Eurylæmids, and which induced Forbes (1880) to relegate them to a separate division of the Passeres under the name of Desmodactyli as opposed to the rest of the Passeres, Eleutherodactyli, in which such a vinculum is absent. When we reflect that no similar vinculum exists, as far as our present knowledge goes, in any representative of the vast Passerine assemblage throughout the length and breadth of the African continent, except in the case of *Pseudocalyptomena* and *Smithornis*, its presence in these two forms is a remarkable phenomenon which can hardly fail to prompt the thought how little may the factors of habit or environment be concerned in the presence or absence of such morphological details. Another feature is the very anomalous character of the scaling on the plantar surface of the tarso-metatarsus; another the unforked condition of the manubrium sterni; another the structural details of the syrinx; and yet another the morphology of the deltoid muscle, to say nothing at all of the special structure of the skull. In all these and other features *Pseudocalyptomena* presents in the most impressive way Eurylæmid characters. Taken in their sum such characters seem to make any question that they exist through the instrumentality of convergent evolution inconceivable, so that the only possible conclusion at which one can arrive is that *Smithornis* and *Pseudocalyptomena* are not only genetically linked with the Broadbills of the Oriental Region, but were also at one time linked in a geographical sense. The question whether this geographical linkage was formerly effected through a common northern ancestor in Eurasia, or whether the African branch of the Eurylæmids represents the relics of a former westerly extension from the Oriental Region dating from the time when Africa and Southern Asia were united by land connections, is one to which an answer cannot be given here. It seems conceivable, however, that they represent westerly outliers of an original Oriental focus of dispersal, since there are indications in *Pseudocalyptomena*, especially in regard to its skull, which may point to its being slightly more generalized than the Oriental Broadbills; for I am inclined to think that there is good reason to suspect that when an animal radiates from its original centre of origin it is the peripheral population which retains to a greater extent its early less specialized characters. If any isolating influence subsequently occurs to cut off the peripheral colonies from the central or original stock, such outlying fringes on the centrifugal wave may be left as witnesses to the evolution of the group. A good example may be quoted in the generalized Snipe forms found in the Chatham Islands (*Cenocorypha*) or in South America [*Xylococa gigantea*, *Chubbia stricklandi* cf. Lowe (1915)].

Another point which I think is brought out in connection with a study

of this strangely isolated little bird is this: If environment in its broadest sense has any effect on the constitution or form of the constituent members of an organism, be they external or internal, other than an indirect or modifying action in a plus or minus direction, which is non-heritable; if, in a word, it has anything more than a survival influence, then it is strange that such a superficial character as the distinctively Eurylæmid coloration of *Pseudocalyptomena* has not ages ago been brought into line with the characteristic coloration of African birds in general. That it has not been brought into line is strikingly evident if we compare its coloration and colour-pattern, as Lord Rothschild has suggested, with those of African birds, or, on the other hand, with that of an Oriental Broadbill species like *Calyptomena hosei*, which it resembles so closely as to suggest unmistakable affinity. In the 'Ibis' (1915) I called attention to the importance of the study of colour-pattern in birds as being very often almost of as much assistance in gaining phylogenetic clues as more deep-seated structures. Among the volcanic peaks of the Kivu district *Pseudocalyptomena* has apparently existed for ages, an obvious Oriental alien, as conspicuously alien as a white man would have been in Central Africa a hundred years ago; and during those ages not a detail of its anatomical "make-up" appears to have been affected in the slightest degree in so far as its likeness to the Eurylæmid picture is concerned. We are probably justified in computing the time during which this African Broadbill has been isolated from its Oriental ancestors in millions of years; yet the effects of environmental action appear to have been absolutely nil. From what we have been able to gather even its habits are likely to turn out to be exactly comparable with those of its eastern congeners. If we compare such a part of its anatomy as the occipital, exoccipital, and basioccipital region with the same region in *Corydon*, the perfect similarity of the delicate transparent texture of the bone, the visibility of the semicircular canals, and the high relief and moulding which these several bones exhibit, is nothing less than amazing, to say nothing of other basal structures, such as the vomer and its relations to the turbinates and maxillo-palatines (see below). Diversity, which we might *à priori* have expected in this isolated species, has not apparently occurred in any part of it, and the conclusion is almost forced upon us that the only factor which can bring about heritable morphological differentiation has its roots in germinal tissue-change and action, and in that only, so that, unless and until "fresh blood" is introduced by crossing of heterozygous gametes, nothing will cause such an isolated species to divert from its original path so long as its environmental conditions enable it to exist at all.

Pterylosis.

The *oil-gland* is not tufted.

Aftershaft.—I could find no trace of an aftershaft in any of the contour or wing-feathers, nor can I find evidence of one in the Oriental Eurylæmids, a fact which appears to have been overlooked.

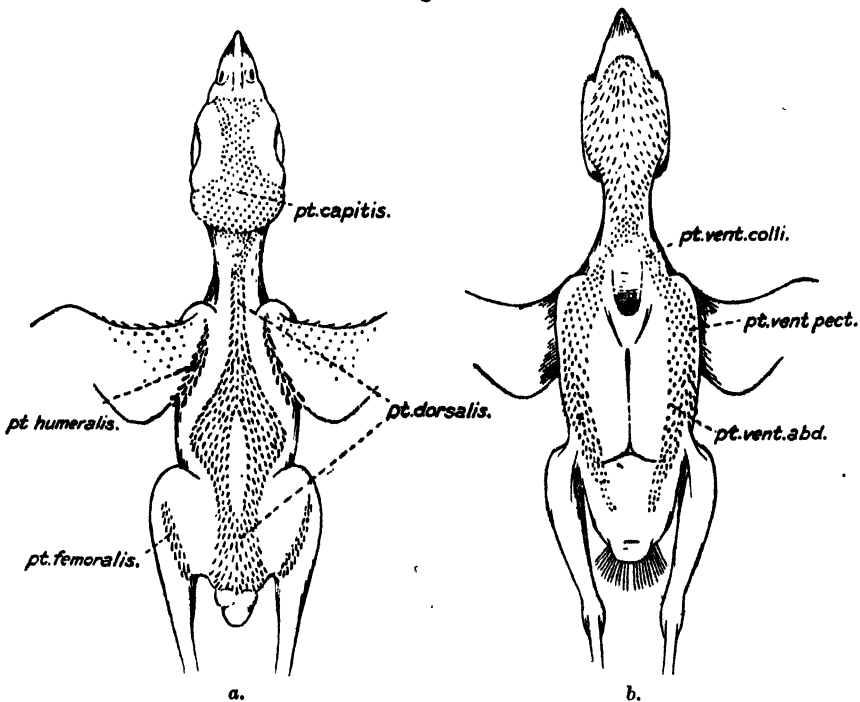
Pteryla alaris.—The wing is eutaxic or quinto-cubital. There are ten primaries and nine secondaries. The tenth or outermost primary is conspicuously long relatively to the rest; it measures 48 mm., while the ninth measures 52 mm. The longest primary is the eighth. The tenth primary is nearly as long as the sixth. The relatively long outermost primary is not characteristic of the normal Passeres, but is, on the other hand, typical of the Eurylæmids. In the 'Catalogue of Birds of the British Museum,' Dr. P. L. Selater divided the Eurylæmidæ into two subfamilies—the *Calyptomeninæ* and the *Eurylæminæ*. He appears to have overlooked the fact that in the former the species have

only nine primaries, in the latter ten. An interesting point to note is that the outer webs of the ninth, eighth, seventh, and sixth are emarginate, the last two rather less so than the former. This emarginate condition is also a Eurylæmid character.

The median wing-coverts of the secondaries have a proximal overlap.

There is no concealed white or coloured patch in the feathers of the mid-dorsal feather-tract such as may or may not occur in the Oriental Eurylæmids. A concealed white patch occurs in the African genus *Smithornis*, as I pointed out in this Journal (1924). In the Oriental Eurylæmids it is present in *Eurylæmus*, *Sarcophanops*, *Cymbirhynchus*, and *Corydon*.

Text-figure 1.



Feather tracts of *Pseudocalyptomena*. $\frac{1}{2}$ nat. size.

Left-hand figure (a), dorsal view. Right hand figure (b), ventral view.

For explanation of lettering, see text.

Pteryia caudalis.—The rectrices number twelve; the two central feathers measure 37 mm., the two outer 34 mm. The tail is therefore comparatively short and squarish. The relative length of the rectrices is very similar to what obtains in the Oriental *Calyptromena*. The under tail-coverts are relatively long, the central pair being nearly as long as the rectrices.

Pteryia capitis.—As will be noted in the figures depicting the feather-tracts of the body (text-fig. 1, a) the *Pteryia capitis* is strongly developed and covers the whole of the upper and under region of the head, with the exception of two crescentic apteria laterally situated to the inner side of the upper eyelids. This condition is practically identical with that found in *Smithornis* and other Broadbills. On the other hand, the riotal bristles are poorly developed, contrary

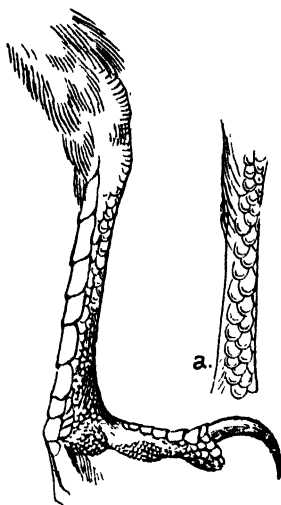
to what obtains in most of the Eurylæmidæ, although they are absent in *Calypdomena* and *Psarisoma*. The loreal region is occupied with closely-packed short stiff and erect feathers.

Pteryla dorsalis.—This tract is strong and presents long and well-developed feathers, except that it terminates abruptly about the middle of the neck, and from thence forwards is almost entirely absent. This latter condition is in keeping with the Eurylæmid character. The saddle-shaped area in the mid-dorsal region (cf. text-fig. 1, a) presents a well-marked apterion. Its posterad limbs consist of three rows of feathers, being in this respect stronger than in most Eurylæmids.

Pteryla femoralis.—This tract is well developed, perhaps noticeably so, for its longest feathers attained to a length of 33 mm.

Pteryla ventralis colli, pectoralis, and abdominalis.—These several parts

Text-figure 2.



Tarso-metatarsus of *Pseudocalypdomena*, to show the abnormal passerine scaling of the podotheca. $\times 2$.

(a) Conical papillomatous scales of the plantar surface more highly magnified.

of the ventral tract are well marked and call for no comment, except that the distinction between the two latter is not so obvious as in most birds, so that it is nearly impossible to differentiate between the outer pectoral and the inner sternal tract in the thoracic area. As a consequence the pectoral tract has the appearance of being very strong and broad.

Rhamphotheca.—The bill and the form and position of the nostrils conform so closely to the typical Eurylæmid character that a detailed description seems unnecessary.

Podotheca.—The acrotarsium is covered with eight or nine transverse scutes, and the plantar surface of the tarso-metatarsus differs from the normal Passerine arrangement in presenting small somewhat conical papillomatous scales (cf. text-fig. 2). This is a very important feature, and entirely in accordance with the Eurylæmid characters of the bird generally. In the higher Passerines the tarsal podotheca are "booted" except in one instance, the Larks (*Alaudidæ*).

The syndactylism between the two outer toes is not so well marked as in Broad-bills as a rule, but is nevertheless quite obvious.

Coloration.—One of the most striking features about *Pseudocalyptomena graueri* is its coloration. This was a point which Lord Rothschild called attention to in the 'Ibis' for 1909, p. 690, where he remarked that its combination of green and blue colours was quite unique among African Passeres. Not only is this so, but this remarkable bird presents a combination of coloration and colour-pattern which is strangely reminiscent of certain species of *Calyptomena*, a combination which can hardly fail to suggest a genetic linkage in the past.

Myology.

(1) *The Deep Plantar Tendons.*—In all the Passeres, as at present known, with the exception of the Eurylæmidæ, there is no vinculum between the tendons of the *flexor longus hallucis* and *flexor perforans digitorum*, these two tendons being completely independent of one another. In the Eurylæmidæ Garrod and Forbes (*loc. cit.*) showed that the tendon of the *flexor longus hallucis* sends a strong vinculum to the tendon of the *flexor perforans digitorum*, as in nearly all other non-Passerine birds in which a hallux is present. I find in *Pseudocalyptomena* that there is a well-developed vinculum which takes the form of a rounded tendinous link. It runs downwards and inwards from the *flexor longus hallucis* to the perforating tendon.

(2) *Tensor patagii brevis.*—There is considerable diversity in various orders of birds in regard to the exact method of insertion of the tendon of this patagial muscle into the *extensor metacarpi radialis longior* muscle. Garrod described and figured some of these methods in the 'Proceedings' of the Zoological Society for 1876, p. 508 *et seq.* He showed that the Passeres are constant, in as far as one hundred and fifty species examined were concerned, in having a certain definite arrangement. This he figured on pl. xlvii. fig. 2. I find in *Pseudocalyptomena* that the arrangement is not comparable with the normal Passerine disposition, but that the tendon of the *Tensor patagii brevis* has almost precisely the same relations with the tendon of the *extensor metacarpi radialis* as it has in the case of *Eurylaimus javanicus*, *Cymbirhynchus macrorhynchus*, and *Calyptomena viridis* (*cf. text-fig. 3*). It is, in point of fact, very closely similar indeed to the arrangement in *Smithornis* which I described in this Journal in 1924 (Pt. I. p. 283). For this reason I shall not go into further details, but refer the reader to the accompanying text-figure.

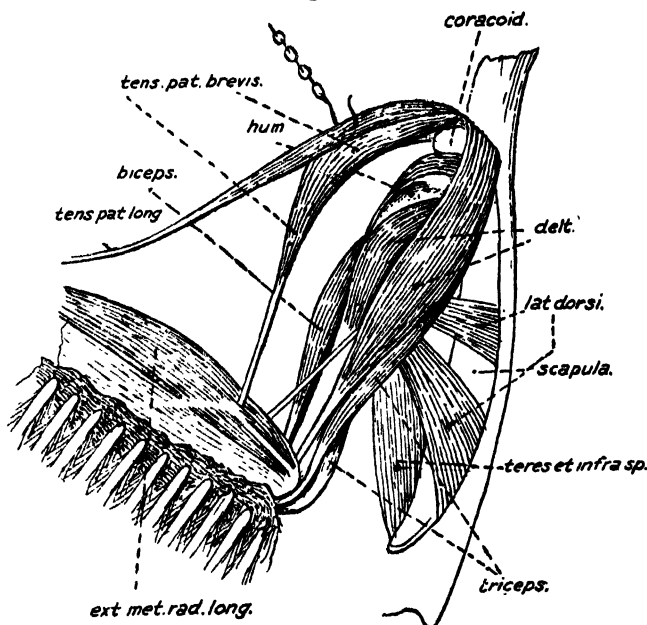
The *Tensor patagii longus* is poorly developed, the tendon along the preaxial patagial fold being almost non-existent.

(3) *The Deltoid Muscle.*—I find on dissection that the *brevis* portion of this interesting muscle arises from the os humero scapularis, and is inserted into the upper part of the anconal aspect of the humerus (*cf. text-fig. 3*). Beyond being somewhat closely associated with the *longus* portion by means of a common connective-tissue sheath, the two portions of the muscle in *Pseudocalyptomena* are quite unconnected, and might, in fact, be regarded as two distinct muscles. The *longus* portion arises in the usual way by a slightly tendinous origin from the contiguous surfaces of the scapula and clavicle. It winds round the back of the shoulder-joint and passes downwards parallel with the *brevis* portion to terminate in a slender tendon which is attached to the proximal side of the ectepicondylar process of the lower end of the humerus. In the Crow (*Corvus*) and other Passeres the *brevis* and *longus* portion of the muscle become gradually blended into a common tendon of insertion. In *Pseudocalyptomena*, *Smithornis*, and the Eurylæmidæ the two portions are entirely separate, the *brevis* division being entirely fleshy and not extending further down the humeral shaft than

its proximal half or less. Contrary to the opinion I expressed when describing the deltoid muscle of *Smithornis* in this Journal (1924, p. 283), I now, after dissecting various other types of birds, agree with Chalmers Mitchell in regard to the *brevis* portion of the avian deltoid, viz., that a relatively short extension, as, for instance, in the Broadbills, indicates an archicentric or primitive condition.

(4) *The Biceps*.—This is a well-developed muscle, and is, I think, quite peculiar in that the tendon of origin is a single, strong, broad, flat, tendinous, glistening band which comprehends within its range the usual areas of origin of the *short* and *long* heads as well as an intermediate area. There is thus

Text-figure 3.



Some muscles of the fore-limb of *Pseudocalyptomena* to show disposition of *Tensor patagii brevis* tendon and other muscles. Enlarged.

For explanation of lettering, see text.

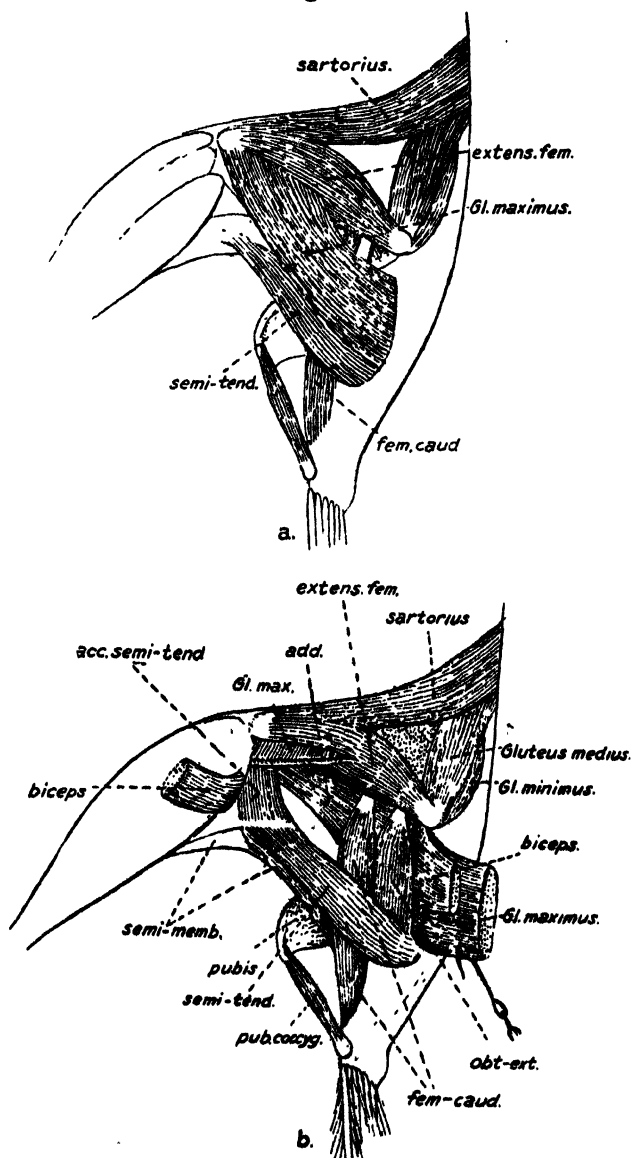
Note.—By an oversight the origin of the two portions of the *Latissimus dorsi* muscles are wrongly drawn.

no division into a *short* and *long* head. The tendinous band is a very definite and strong one, and I imagine this condition to be archicentric to the more advanced specialized double-headed origin. In the Broadbills the short humeral head does not appear to have been developed as far as one may judge from the condition in *Eurylaimus javanicus*, *Calyptomena viridis*, and *Eurylaimus ochromelas*. There is no biceps slip in *Pseudocalyptomena*.

(5) *Expansor secundariorum*.—Not present.

(6) *Pectoralis major, secundus, and minor*.—The first of these muscles is remarkable for its great size and thickness. Besides occupying to the full extent the usual areas of origin on the sternum and clavicle, it overflows, so to speak, on to the thoracic rib-muscles, to which it seems to get a spurious attachment. The general condition is exactly as in the Broadbills. The *Pectoralis*

Text-figure 4.



Some muscles of the thigh of *Pseudocalyptomena*. Enlarged.

For explanation of the lettering, see text.

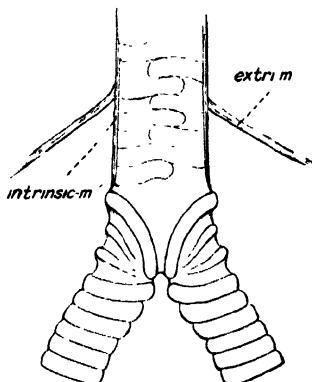
In *b* the muscles are represented as seen after removal of the more superficial muscles shown in *a*.

secundus is not a very well-developed muscle, and the tendon which winds through the foramen triosseum is feeble. This is an interesting point, in view of the fact that this muscle is the great elevator of the wing and that the Broadbills are very sedentary birds. The *Pectoralis minor* had exactly the same form, shape, and proportions as in *Eurylæmus ochromelas*.

(7) The *subscapularis* is another surprisingly large and powerful muscle in *Pseudocalyptomena*.

The Muscles of the Thigh (cf. text-fig. 4, a & b).—The ambiens and accessory femoro-caudal are not represented. The semitendinosus, accessory semitendinosus, semimembranosus, and femoro-caudal are well developed. I could not find the usual sling at the insertion of the biceps. The *Gluteus maximus* lacked the usual aponeurotic extensions, and is a fleshy nearly rectangular muscle, which has an almost independent existence except where it merges into the extensor femoris mass. Its origin is confined to the postacetabular ridge of the pelvis. In text-fig. 4, b, the muscles are represented as seen after dissection and removal of the more superficial gluteus maximus and biceps.

Text-figure 5.



To show the syrinx of *Pseudocalyptomena* with extrinsic and intrinsic muscles. Enlarged.

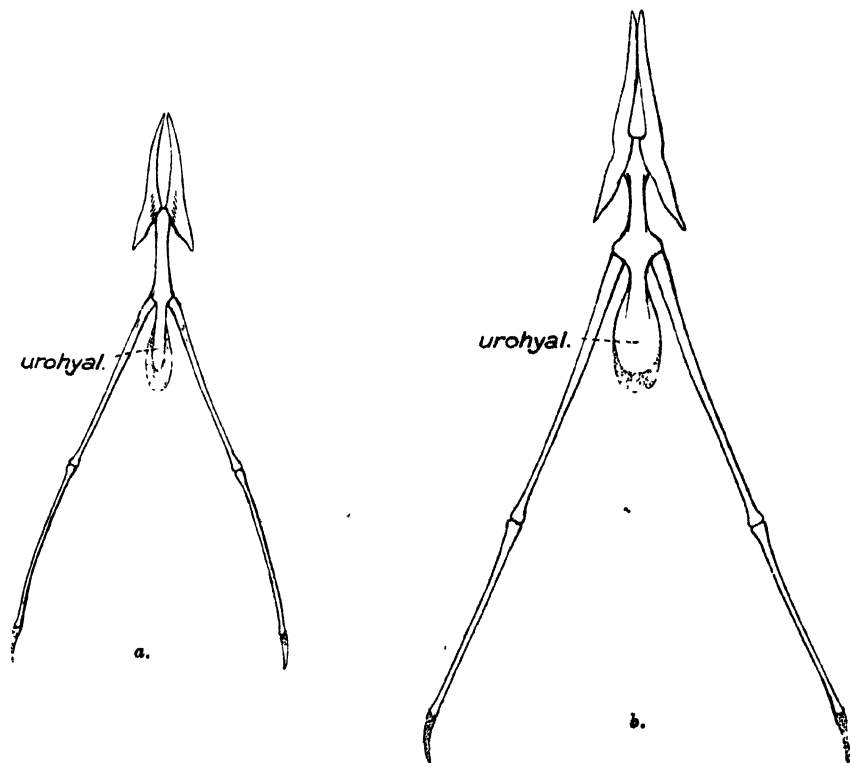
The Syrinx is tracheo-bronchial. The extrinsic muscles are represented by a pair of slender sterno-tracheal muscles which originate at the level of the last ring but four which are visible and are inserted on to the costal process of the sternum. The intrinsic muscles are represented by but one pair, which is inserted into the middle of the first bronchial semi-ring. This pair of muscles is extremely poorly developed, so much so that it was some time before I could convince myself that it existed. It seems to split and embrace the origin of the sterno-tracheal muscle of either side.

The last two or three tracheal rings appear to have been fused so as to form a triangular box-like ending to the trachea. The apex of this triangle is prolonged downwards both in front and behind (cf. text-fig. 5); a pessulus is present and well developed. The last few tracheal rings having a separate existence are not complete and interdigitate. The first pair of bronchial semi-rings are rounded, well developed, considerably arched, and concavo-convex, with the concavity downwards. The next two rings are shorter, more slender, and so approximated as to have above and below them a conspicuously wide membranous expansion or fenestral space. The fourth ring

is thicker and more ring-like than the three above, and is concave upwards. The fifth and succeeding rings are of equal thickness and width; they continue downwards, until finally they become complete.

Forbes has figured the syringes of *Eurylæmus ochromelus* and *Cymbirhynchus macrorhynchus* (P. Z. S. 1880, pp. 384–385), and of these two the latter is more specialized and very similar in structure and form to *Pseudocalyptomena*; but on p. 389 of the same volume he gives a figure of the syrinx of *Philepitta castanea* which seems to me in several respects to be, strangely enough, even

Text-figure 6.



To show the hyoid apparatus of (a) *Pseudocalyptomena* (left-hand figure),
(b) *Picathartes* (right-hand figure). $\times 2$.

more closely similar, for there is no reason to regard *Philepitta* as a member of the Eurylæmid group of Passeres.

The Hyoid Apparatus.—Attention is drawn to that portion of the hyoid apparatus known as the urohyal (cf. text-fig. 6, a & b). In the 'Ibis' for 1914 Mr. G. L. Bates called attention to the morphology of this little bone in the group of Passeres. He there states that it has a peculiar shape in all "normal Passeres": "In these the free end of the urohyal is very flat, with a thin border of cartilage at the edges and tip. The amount of this flattening and widening varies among the families of Passeres, but there is a similarity in this regard between members of each family. The Pycnonotidæ have the

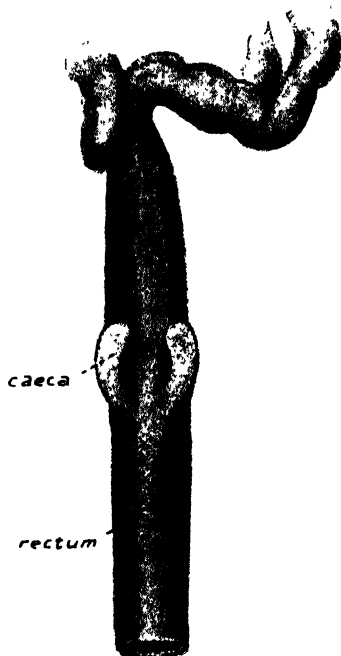
urohyal the widest and flattest of any of the birds I have observed, and the Muscicapidæ the least so, but even where least marked the characteristic shape is unmistakably seen." I find that in *Calyptomena*, *Eurylæmus*, and *Psarisomus* the only Oriental Broadbill genera in which I have had the opportunity of dissecting the hyoid, the urohyal is a long, slender, styloid process, with a very narrow border of cartilage at the edges and tip; so it is in the African *Smithornis*. In *Pseudocalyptomena*, on the other hand, it is wider and more blade-shaped, though not so wide as in the Pycnonotidæ (*P. tricolor*), and still less as compared with the urohyal in an African Passerine like *Picathartes*, whose urohyal has been figured for comparison.

Alimentary System.

The Tongue is bifid and horny at the tip, and in general configuration triangular or cordate, its two posterad angles being prolonged into two fleshy projections armed with spiny processes.

The soft palate is likewise studded with such processes directed backwards.

Text-figure 7.



To show the colicæca of *Pseudocalyptomena*.

The proventriculus is zonary, but the zonal band of glandular epithelium is at its posterad end. It is sharply constricted from the gizzard, which is lined with a plicated and hardened epithelium of a dark brownish coloration, disposed in curious paired folds longitudinally arranged. The transition from the soft glandular epithelium of the proventriculus is curiously abrupt. The walls of the gizzard are neither very thick nor muscular, and contained a closely packed mass consisting of the remains of insects. In this respect it may be noted that some of the Broadbills are frugivorous, others insectivorous.

There are two main intestinal loops, which are simple or Passerine in structure, viz., a duodenal and a Meckel's tract, which includes the proximal or supraduodenal loop. This last ends at the cæca, and is, as usual, immediately followed by the rectum.

In Meckel's tract proper there are two subsidiary coils. I could not find any indication of a Meckel's diverticulum in this part of the tract. I have followed Mitchell (1901) in his nomenclature of the various divisions of the intestinal tract.

There were two colic cæca (cf. text-fig. 7) situated 15 mm. upwards from the anal orifice.

The rectum is straight and simple.

The liver is bilobed, the right being the larger.

Vascular System.—The carotid artery is present on both sides, but is not apparently so strongly developed on the right. The chief artery of the lower extremity is represented by the sciatic.

Osteology.

As regards the osteology of *Pseudocalyptomena*, what has already been said of the osteology of the Eurylæmids by Pycraft (1905) and of *Smithornis* (1924) by myself might, in a general sense, have been equally well written for the form under discussion. To describe at any length the osteological features of *Pseudocalyptomena* would therefore to all intents and purposes imply a repetition of the osteological characters of the Broadbill. This would be tedious for the reader, who is referred to the papers quoted in the summary of literature, and I shall accordingly confine myself to a few outstanding points.

Sternum.—The Eurylæmids have always been recognized as differing from the rest of the Passeres by not possessing a bifurcate free end to the *spina externa* (cf. P. L. Selater, 1872). *Pseudocalyptomena* in this respect conforms to the Broadbills, if, indeed, such a character has any very definite value, for in some of the genera there is more than a mere potentiality to bifurcation, while in *Smithornis* it is as pronounced as in the true Passeres. Nevertheless it cannot be anything less than impressive to find in *Pseudocalyptomena* the same blade-shaped *spina externa* as in *Calyptomena*, no *spina interna*, and a sternum with a general shape and form which might be that of *Calyptomena* itself. The two coracoids are separated from each other by the *spina externa*, and the coraco-sternal articular groove is disposed almost at right angles to the mid-sternal line, so that it looks nearly directly forwards, both of which characters, especially the last, are characteristic of the Eurylæmids. The form and method of grafting of the hypocleidium on to the fore part of the sternum might be that of *Corydon*, as might also be the bowed form of the clavicle.

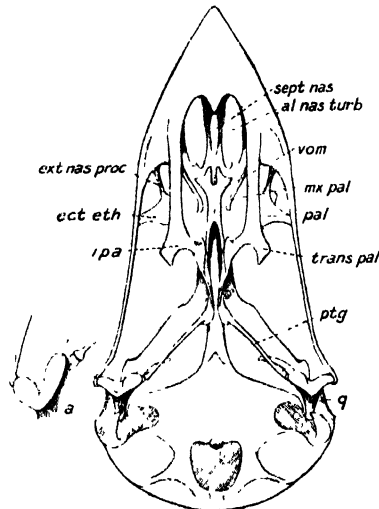
The Skull.—Although in the general form and configuration of the several parts of the skull—preorbital, midorbital, and postorbital—*Pseudocalyptomena* presents us with a definitely Eurylæmid picture, it is not perhaps quite so specialized, especially in the preorbital region, as in such genera as *Corydon* or *Cymbirhynchus*. Its nasal hinge, however, is very definitely Eurylæmid, while the morphology of its nasal bones is very nearly as distinctive and specialized as in *Corydon*, and that is saying a great deal. These nasal processes, the conformation of the ectethmoid processes, the absence of any sign of a lacrymal, and the large narial openings are unmistakably Eurylæmid, although it should be added here that in *Calyptomena*, the genus typical of one of the two Eurylæmid subfamilies, a lacrymal is present. The maxillo-palatines are very slender and delicate processes directed backwards and inwards, not

transversely disposed as in *Cymbirhynchus*, ending in a very slight expansion at their distal ends, and bound by a ligamentous band to the interpalatine spurs. In the text-figure one maxillo-palatine process (the right) has been left in its natural position; in the other the connective-tissue sheath has been dissected away, leaving nothing but the skeleton. The palatines, transpalatines, prepalatal bars, interpalatine spurs, and ethmopalatine laminae might almost be those of *Cymbirhynchus*.

The pterygoids are rod-shaped and impinge against the parasphenoidal rostrum by an expanded pedate seating, which is continued forwards along either side of the rostrum as a long and slender hemipterygoid-like slip.

The Vomer is a relatively large and well-ossified body, slightly convex on its inferior surface and flat above, with no upturning of its antero-lateral

Text-figure 8.

Ventral view of basi-cranium of *Pseudocalyptomena*. $\times 2$.

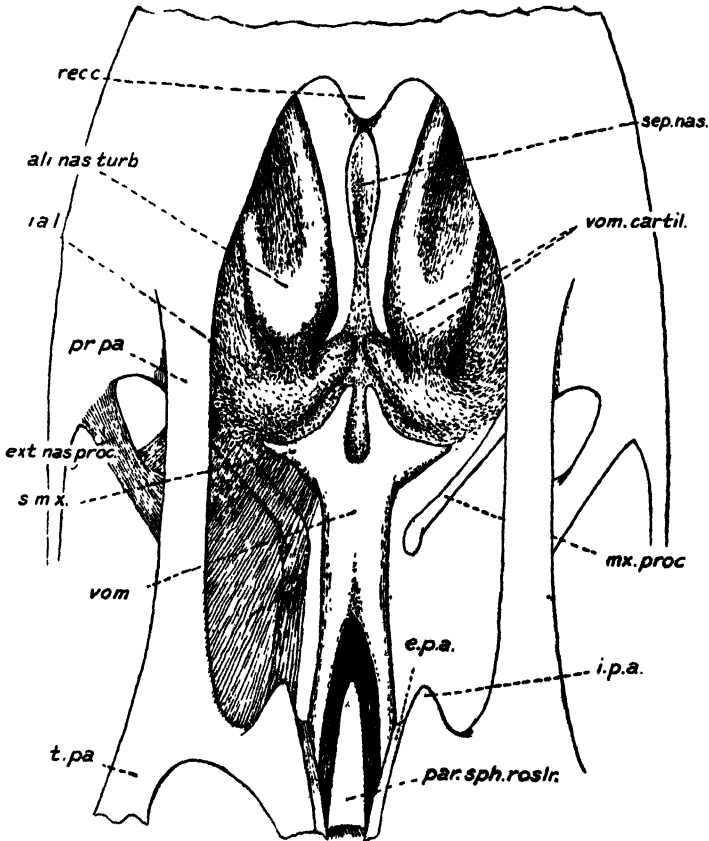
sept.nas., septum nasi; *al.nas.turb.*, ali-nasal turbinal; *vom.*, vomer; *ext.nas.proc.*, external nasal process; *ect.eth.*, ectethmoid process; *i.p.a.*, interpalatine spurs; *mx.pal.*, maxillo-palatine process; *pal.*, palatine; *trans.pal.*, transpalatine process; *ptg.*, pterygoid; *q.*, quadrate.

(a) To illustrate the relations of the two articular surfaces at the lower end of the quadrate in the higher passerines as compared with their relations in the Eurylemidae.

or lateral margins. It terminates behind in two divergent limbs or crura, which fuse with the ethmo-palatine laminae. Anteriorly it is continued forwards as two prominent cornua whose internal borders run parallel to one another, but whose outer margins are continued outwards and backwards until they merge in a prominent and acute lateral horn (cf. text-figs. 8 & 9). This antero-lateral border of the lateral vomerine projection has a crescentic shape, is slightly grooved, and has somewhat swollen and rounded margins. The lateral horn is not welded to the maxillo-palatines by any cartilaginous union such as occurs in higher Passerines like the crows, grackles, starlings, etc., but is connected by loose, indifferent, unchondrified connective tissue with the inturned alinasal. This latter in turn lashes itself, so to speak, to the dorsal surface of the maxillo-palatine.

Forwards and outwards of the two crescent-shaped apophyses of the vomer above described, and connected with them by indifferent tissue, are two, irregularly-triangular masses of hardly chondrified material (see text-fig. 9). They converge on either side, so that their fore ends or apices lie almost in contact in the middle line and some little way anterad of the two anterior

Text-figure 9.



Enlarged ventral view of vomerine region in *Pseudocalyptomena* to show relations of vomer, etc. Much enlarged.

rec.c., recurrent cartilage; *sep.nas.*, septum nasi; *ali.nas.turb.*, alinasal turbinal; *i.a.l.*, inturned ali-nasal; *vom.cartil.*, vomerine cartilage; *pr.pa.*, prepalatine pars; *ext.nas.proc.*, external nasal process; *s.m.x.*, septomaxillarius; *vom.*, vomer; *t.pa.*, transpalatine; *mx.proc.*, maxillo-palatine process; *e.p.a.*, ethmo-palatine lamina; *i.p.a.*, interpalatine apurs; *par.sph.rostr.*, parasphenoidal rostrum.

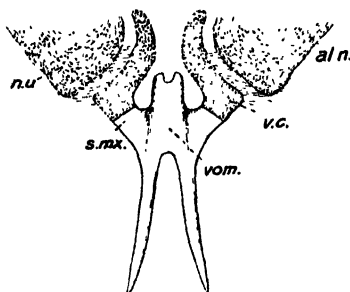
cornua of the vomer. The question whether these may be persistent relics of the vomerine cartilages I put forward in the most tentative way, the question being suggested by a curious likeness to the morphological conditions seen in the vomer of the young *Turnix* (cf. text-fig. 10).

Still further forwards and outwards and beyond the bodies just described may be seen the alinasal turbinals. These spring from the alinasal wall by

a constricted neck of loose connective tissue which gives them free play. The position of these turbinals is on the same level as, almost flush with, the widely separated prepalatine bars and the inferior surface of the vomer itself. Thus it is in great contrast with the condition seen in the higher Passerines. So also is the comparative state of freedom of the vomer itself, which, instead of being attached to the maxillo-palatines by cartilaginous union or "welding," is slung and held in position, as it were, by unchondrified connective tissue passing outwards, on the one hand, from the extremities of the lateral horns to the alinasals and maxillo-palatines, and forwards, on the other hand, from the apices of the anterior cornua to the nasal septum.

Thus in the Broadbills, judging only by *Pseudocalyptomena*, the vomer is "free"; in the higher Passerines, judging only by a series of examples of Corvidæ, Eulabetidæ, and Sturnidæ, it is welded, or, as it were, "soldered" to the maxillo-palatines, so as to be rendered completely fixed and immobile. Finally, at the apices of the antero-lateral horns above described appears some differentiated semi-ossified or semi-chondrified tissue, which suggests itself to me as the still segmented septo-maxillaries of either side.

Text-figure 10.

The vomer of a young *Turnix* and its relations (after Kitchen Parker).

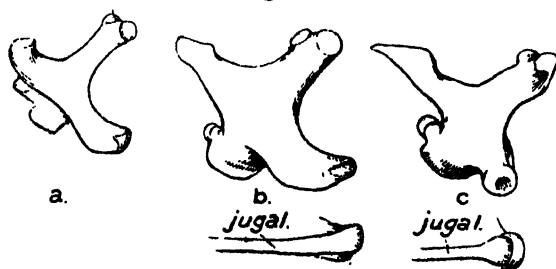
s.ma., septomaxillary; vom., vomer; v.c., vomerine cartilage; al.n., alinasal turbinal.

As far as concerns the relations of the vomer to surrounding structures, as above described, the nearest approach to it, as far as I have been able to discover, appears to be met with in *Turnix* (Hemipodes or Turnicomorphs), which it will be remembered is ægithognathous or partially so. There is an illustration of this Turnicomorphine vomer in a paper by Kitchen Parker (1877) on "Ægithognathous Birds" which I have reproduced here (cf. text-fig. 10). It need hardly be said that this resemblance is not called attention to in order to suggest affinity between the two forms, but it does seem to suggest the same sort of low evolutionary status which is quite in keeping with the position of the Eurylæmidæ in relation to the rest of the Passeres. Pycraft (1905, p. 50), in his paper on the osteology of this family, thinks that "the vomer presents a number of gradations in the direction of reduction and degeneracy." He does not specify these, and in view of the fact that the vomer and its relations in *Pseudocalyptomena* so obviously indicate a low evolutionary status, one is compelled to disagree with the statement. Pycraft (*loc. cit.* p. 52) also seems to think that it is "open to question whether so wide a separation as the division of the Passeres into the two groups Desmodactyli (Broadbills) and the Eleutherodactyli is justified." My studies lead me to think that it is not so much a question whether these two divisions are justified or not, but as to whether the Broadbills have any right to be included in the Passeres at all.

Squamosal Region.—Although the temporal fossæ are not so deeply grooved as in *Corydon* and *Cymbirhynchus*, they are quite as much so as in *Calyptomena*, and the squamosal prominence is as well marked as in that last genus. The zygomatic process is also as well developed as in *Calyptomena*, and so is the articular process of the squamosal.

The Occipital Region.—The amount of sculpturing and high relief in this region is very marked—exceptionally so—and I mention it because it is so in *Corydon* especially; so that the resemblance in this respect between *Pseudocalyptomena* and *Corydon* is more than a little remarkable. I spare the reader further details.

Text-figure 11.



To illustrate junction of quadrato-jugal with quadratal spur.

- (a) *Pseudocalyptomena*; (b) by symphysis in Eurylæmids; (c) by cup and ball articulation in higher Passerines, e. g., in starling (sternus).

The Mandible is typically Eurylæmid: there is a complete fusion of the several bones, and no foramen between the surangular, angular, and splenial, or if present at all it is merely potential.

The Quadrate.—In his description of the quadrate in his paper on the osteology of the Eurylæmidæ Pycraft (1905) says "the quadrate is peculiar in that, in common with the Tyrannidæ and some other Passerine forms, it sends out a strong spur for the articulation of the quadrato-jugal bar. This spur projects like a buttress laterad of the outer condyle for the lower jaw." This may be perfectly true, but I do not think it adequately represents the morphological differences between the Eurylæmids and the rest of the Passeres in regard to this region, since all the Passerines I have casually examined have spurs which project in this way in either a greater or lesser degree. There are, however, two points in which the morphology as regards the lower end of the quadrate differs in the Eurylæmids from the rest of the Passeres:—

- (1) In the Eurylæmids the two articular surfaces at the lower end of the quadrate are disposed much more nearly in the same straight line, which is very nearly at right angles to the antero-posterior mid-plane of the skull; while in the higher Passerines the articular surfaces are inclined at an acute angle to each other (cf. text-fig. 8, a).
- (2) In the Eurylæmids the quadrato-jugal makes junction with the outwardly projecting spur at the lower end of the quadrate by means of what is nearly a symphysis; whereas in such forms as the crows, starlings, etc. there is a cup-and-ball joint. I have tried to represent this in text-fig. 11, where it may be noted that, in respect of the above-described characters, *Pseudocalyptomena* exhibits a Eurylæmid likeness, which, in view of its geographical isolation through so many hundreds of thousands of years, is not a little remarkable.

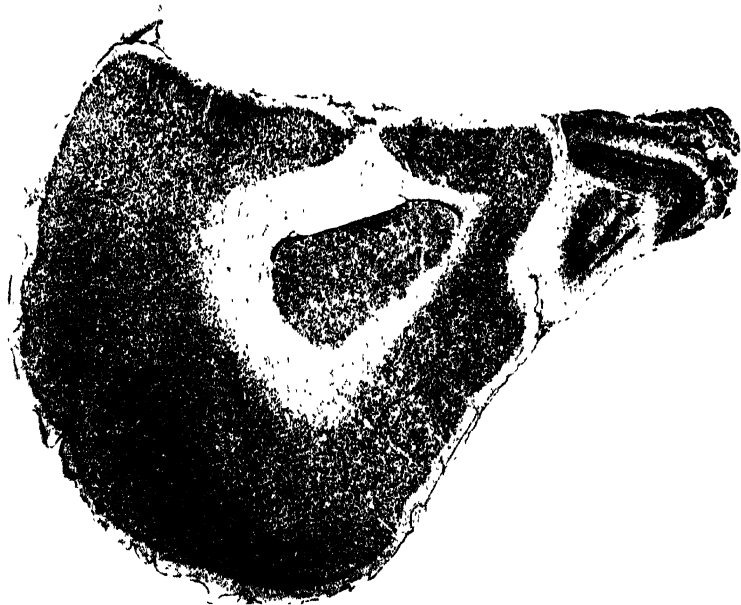
The Vertebral Column.—There are twelve cervical vertebræ and three cervico-thoracic, of which the ribs of the first (most anterad) are vestigial although presenting a distinct capitulum, a tubercle, and remnants of a shaft; those of the second have no uncinatæ processes or sternal segments, while those of the third have well-developed uncinate processes and a sternal segment which is not connected with the sternum. This condition is Eurylæmid.

Next follow four thoracic vertebræ, posterad of which is another "thoracic" which has become merged into the synsacrum, and then, in order from before backwards, two lumbar, three (?) lumbo-sacral, two sacral, four caudals, and eight free caudals.

Considerable time and space might be consumed in describing at length the morphological details of this vertebral column; but I shall confine myself to the simple statement that I have compared it with that of *Calypptomena whiteheadi*, and that as a result I find the resemblances very remarkable indeed. Indeed, if we take all the points mentioned by Pycraft (*loc. cit.*) as being characteristic of the Eurylæmids, we find them present in *Pseudocalypptomena* without exception. For instance, there are hypapophyses in both forms on the second, third, fourth, and fifth cervical vertebræ, and again after a gap from the eleventh to the sixteenth inclusive; and so on. There is, in fact, hardly a detail in which the vertebral column of the two species do not agree. When we consider the extraordinary diversity exhibited in the morphological details of the spinal column even in birds of the same groups this similarity is very striking.

LITERATURE.

- SCLATER, P. L. 1872. Observations on the Systematic Position of the Genera *Peltops*, *Eurylæmus*, and *Todus*. *Ibis*, vol. ii. pp. 177-180.
- SCLATER, P. L. 1888. Eurylæmidæ: Catalogue of Birds British Museum, vol. xiv. p. 454.
- PARKER, KITCHEN. 1877. On Ægithognathous Birds.—Part I. *Trans. Zool. Soc.* ix. pl. liv. fig. 8.
- GARROD, A. H. 1877. On some Anatomical Peculiarities which bear upon the Major Divisions of the Passerine Birds.—Part I. *Proc. Zool. Soc. London*, pp. 506-519, pls. xlviii. liii.
- FORBES, W. A. 1880. Contributions to the Anatomy of Passerine Birds. Part II. On the Syrinx and other Points in the Anatomy of the Eurylæmidæ. *Proc. Zool. Soc. London*, pp. 380-386. Ditto.—Part III. On some Points in the Structure of *Philepitta*, and its Position among the Passeres. *Proc. Zool. Soc. London*, pp. 387-391.
- MITCHELL, CHALMERS. 1901. On the Intestinal Tract of Birds; with Remarks on the Valuation and Nomenclature of Zoological Characters. *Trans. Linn. Soc. Lond.* pp. 173-275, pls. xxi. & xxii.
- PYCRAFT, W. P. 1905. Contributions to the Osteology of Birds.—Part VII. Eurylæmidæ; with Remarks on the Systematic Position of the Group. *Proc. Zool. Soc. London*, vol. ii. pp. 30-38, pl. ii.
- ROTHSCHILD, HON. WALTER. 1909. Description of a new Bird from Africa, *Pseudocalypptomena graueri*. *Ibis*, pp. 690-691.
- BATES, G. L. 1914. Some Facts bearing on the Affinities of *Smithornis*. *Ibis*, pp. 495-502.
- LOWE, P. R. 1915. Coloration (and Colour Pattern) as a Factor in Family and Generic Differentiation. *Ibis*, pp. 320-346.
- LOWE, P. R. 1915. On the Osteology of the Chatham Island Snipe, *Cercocorypha pusilla* Buller. *Ibis*, pp. 690-716.
- LOWE, P. R. 1924. On the Presence of Broadbills (Eurylæmidæ) in Africa. *Proc. Zool. Soc. London*, pt. i. pp. 279-291.



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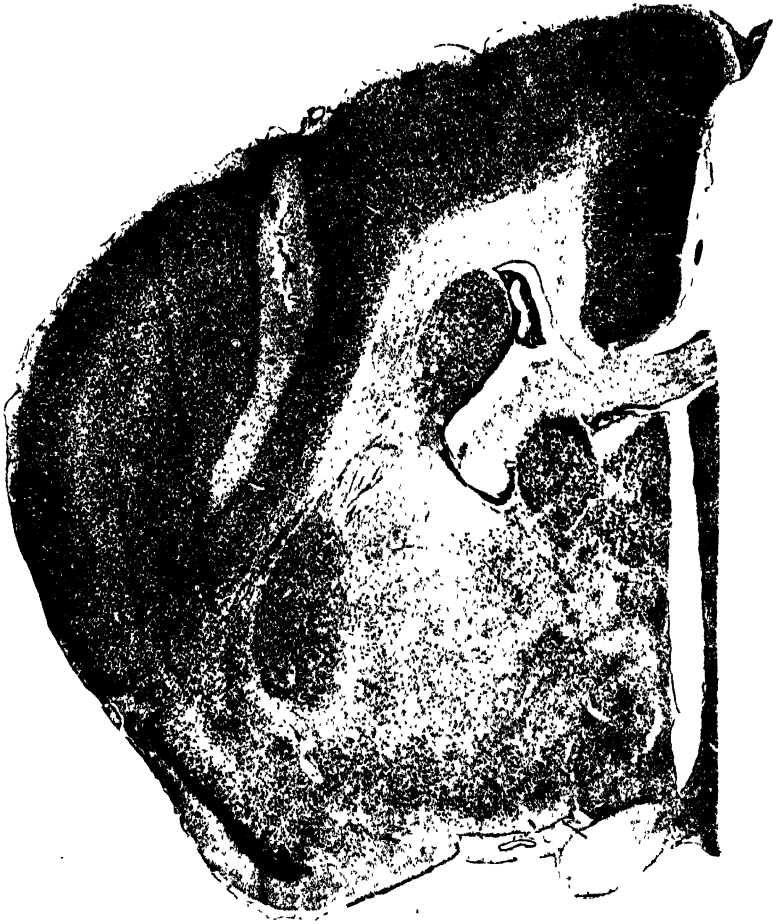
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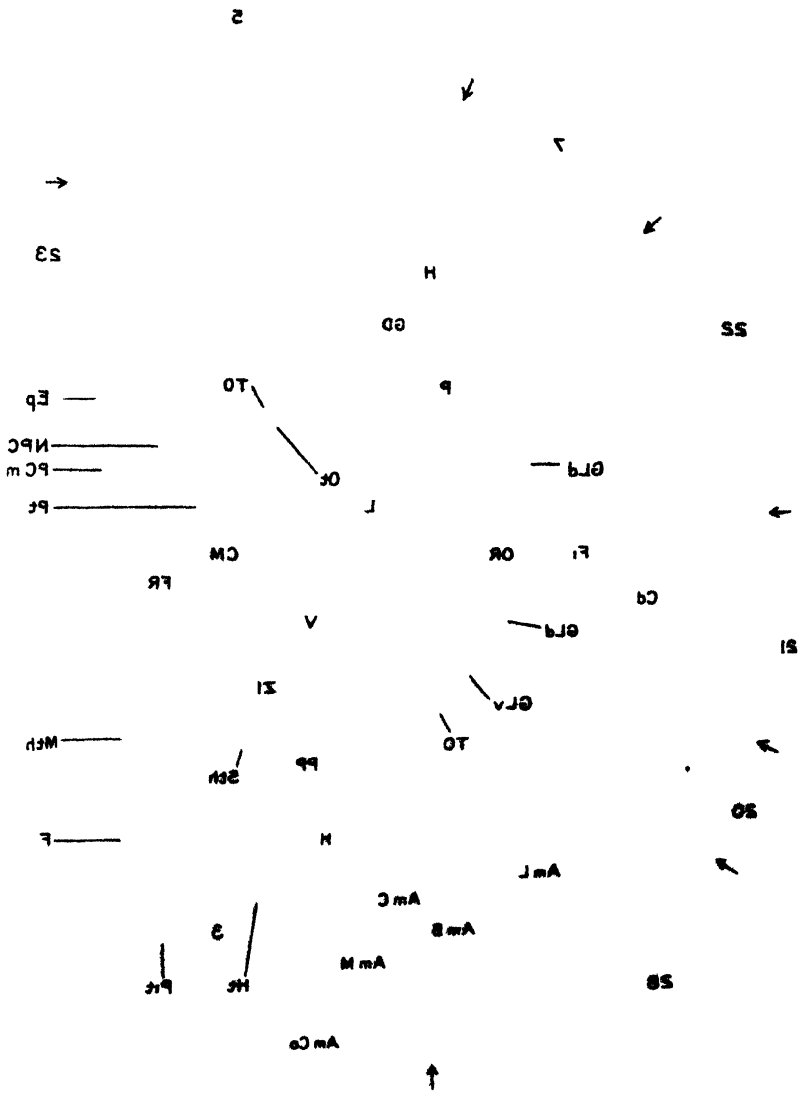
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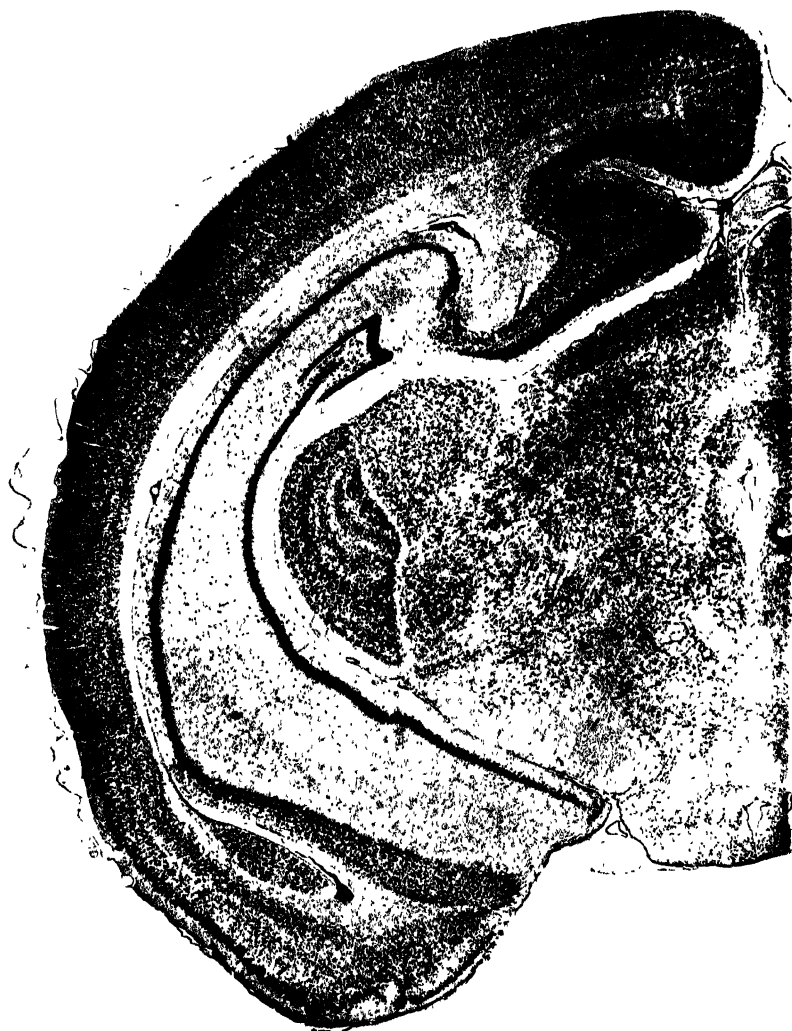




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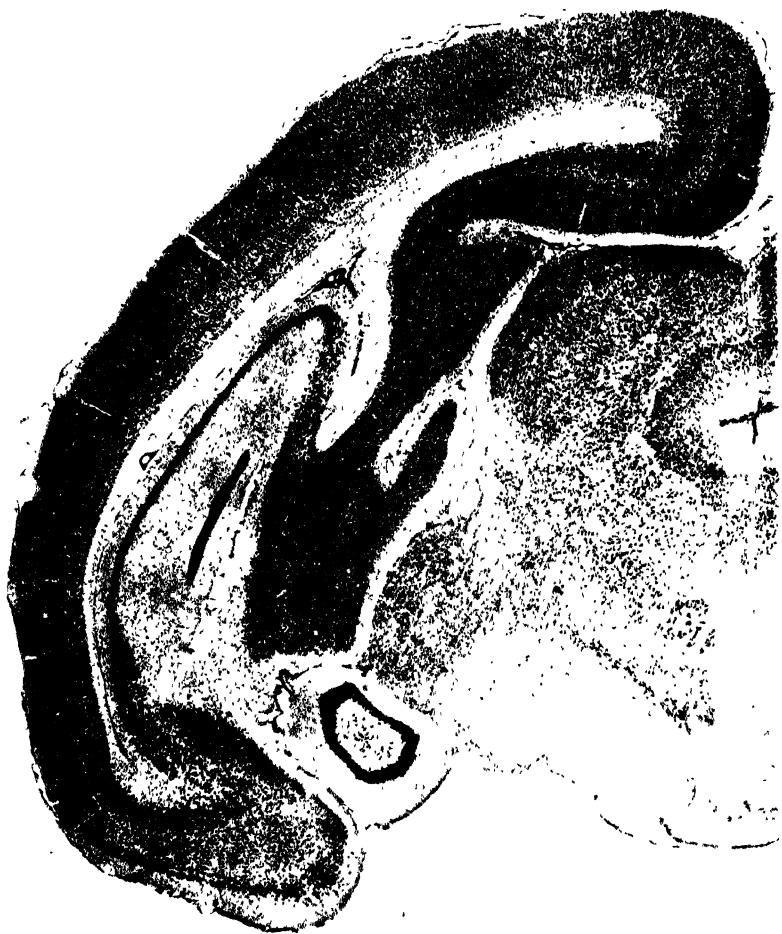
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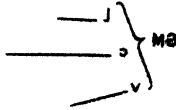
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23. The Brain of *Microcebus murinus*.

By W. E. LE GROS CLARK, D.Sc., F.Z.S.

Received February 7 1931 Read April 28, 1931.]

(Plates I.-VIII.*; Text-figures 1-7.)

The order of the Primates is commonly divided into three suborders, Anthropeidea, Tarsiodea, and Lemuroidea. On the nature of the relative affinities of these three groups, however, there is much difference of opinion, and the difference is in part dependent upon the particular structural features which may be employed for assessing these affinities. The problem is further complicated by the difficulty of determining whether morphological resemblances are the result of derivation from a common type or of a parallelism in evolutionary development. In order to minimise these difficulties it is of advantage to study the most primitive members of each group for the purpose of comparison. In this way the fundamental subordinal differences may more readily be detected before they are obscured by generic and specific specialization, whether divergent or convergent. Moreover, the most primitive existing representatives of a group are likely to give a more reliable indication of the nature of the ancestral type from which the group originated, in so far as it is true to say that the progenitor of any natural group of animals must have been at least as primitive and generalized as the most primitive known member of that group. Applying the same conception to individual organs (and even parts of organs) it may be inferred that in the common progenitor any organ must have been at least as primitive structurally as its most primitive homologue in known members of a natural group. This argument is but a corollary of the well-known Law of Irreversibility in Evolution. Several observers have drawn attention to what they believe to be outstanding exceptions to this law, but, even if a true reversal may occur in evolution, it is probably a sufficiently rare phenomenon, such as may be ignored in discussions of a general nature. Especially is this likely to be the case in regard to the central nervous system. Since a progressive elaboration and differentiation of the higher levels of the central nervous system indicate increased powers of apprehending the nature of external stimuli, a capacity for a wider range of adjustments to any environmental change, and an enhancement of the neural mechanism for effecting more delicately co-ordinated reactions, it is difficult to believe that, when such advantages have been gained during evolutionary development, they can again be dispensed with, unless their disappearance is accompanied by very extreme forms of specialization in other directions. If Natural Selection plays a significant rôle in the direction of evolutionary development, it can hardly fail to be a potent factor in the prevention of retrograde changes in the most important controlling centres of the brain. We may infer, then, in a general way, that the structure of the brain of the earliest Primates must have incorporated the primitive features of the most primitive types of brain in the known Primates, and a similar statement might be made with regard to the three suborders of this group. In order, therefore, to be in a position to draw conclusions regarding the cerebral attainment of the ancestral Primates it is

* For explanation of the Plates, see p. 485.

essential first of all to be in possession of the details of the anatomy of the most primitive brains of the existing suborders.

A knowledge of the simplest types of Primate brain, moreover, provides a basis for a more accurate comparison with the brain of those Insectivora which show certain structural resemblances to the lower Primates, and which have been regarded by some observers as approximating in some degree to the mammalian type from which the Primate stock has been derived.

The most primitive type of brain to be found within the limits of the Anthropoidea is that of *Hapale*, and of this we know many details in regard to macroscopic and microscopic structure from the studies of Elliot Smith (8), Brunner & Spiegel (3), Brodmann (1), etc. The suborder Tarsioidea is represented, so far as the knowledge of the brain is concerned, by *Tarsius* only, and here again a considerable amount of information in regard to its gross and minute structure is available from the researches of Elliot Smith (9), Ziehen (23), Woollard (18, 19, 20), Tilney (17), and the writer (7). The most primitive type of lemuroid brain is found in *Microcebus*, a small Madagascar Lemur. So far as some of the macroscopic features of the brain are concerned, a short account was given by Elliot Smith in his classic memoir of 1902, but no details of the internal structure of this interesting brain are available. It is for these reasons that the opportunity has been taken in this paper to place on record a more detailed account of the brain of *Microcebus*. This opportunity has been rendered possible by the gift of a well-preserved specimen of this small lemur to the writer by the Zoological Society of London.

MATERIAL.

The specimen of *Microcebus murinus* upon which this study is mainly based was received by the Zoological Society on Feb. 19th, 1930, and died on Oct. 13th, 1930. Owing to the kindness of Dr. G. M. Ververs, Superintendent of the Zoological Society, the specimen was delivered to me in a solution of 10 per cent. formalin within six hours of death. The roof of the skull was removed piecemeal to allow the formalin access to the cranial contents, and twenty-four hours later the brain was removed and its surface features studied with a binocular microscope. The weight of the brain was found to be 2.46 grams, the weight of the whole animal being 89 grams. This gives a ratio of brain-weight to body-weight of 1/36. In a fresh adult specimen of *Tarsius* of approximately the same body-weight, i.e., 92.5 grams, the brain weighed 3.6 grams, giving a ratio of 1/26. It may be noted also that in *Tupaia minor* the ratio was found to be 1/26, but the body-weight of this insectivore is about half that of *Microcebus*.

GENERAL REMARKS.

The brain was found to be excellently preserved and hardened. Drawings of various aspects were made to scale by means of a binocular microscope, and are here reproduced. The length of the whole brain from the tip of the olfactory bulbs to the caudal end of the medulla was 23 mm., while the maximum breadth was 18 mm. All the cranial nerves (with the exception of the oculomotor nerve of the left side) were preserved intact. It is interesting to note that the left optic nerve showed complete degeneration of the myelin sheaths, and was represented by a thin translucent grey strand. The white appearance of the normal optic nerve was in marked contrast, and a close examination under the dissecting microscope enabled one to see that a relatively large proportion of the fibres of the right optic nerve passed into the optic tract of the homolateral side (text-fig. 3). A few of the serial sections at this level were mounted

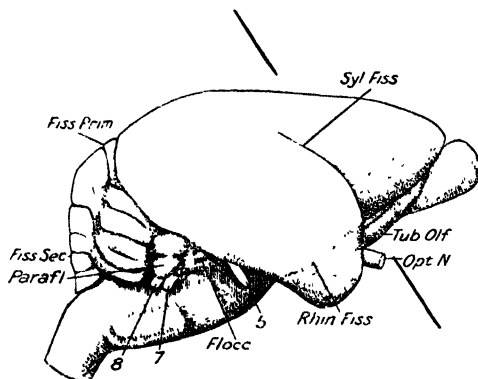
on separate slides and stained with iron-haematoxylin in order to determine the proportion of the optic fibres which remained uncrossed at the chiasma. The staining of the myelin sheaths and the plane of the sections were not appropriate for deciding this point accurately, but it is possible to say that the decussation of the optic fibres is very incomplete.

After examination of the brain as a whole the hind brain was removed by section of the brain-stem immediately below the inferior colliculi, and the left cerebral hemisphere was cut away, leaving the thalamus intact. This allowed a superficial study of the thalamus and the medial aspect of the hemisphere and the cerebellum. The main part of the brain was then hardened for two days in 95 per cent. alcohol, to which had been added 5 per cent. acetic acid, and embedded in paraffin in the usual way. Transverse sections, at $15\ \mu$ thickness, were cut serially through the whole of the cerebrum and stained with Borell's methylene blue, with very favourable results. A few longitudinal sections were also made through the left cerebral hemisphere, which had been previously removed from the main block.

CEREBRAL HEMISPHERE.

The general shape of the hemispheres is indicated in the accompanying figures. Their greatest breadth is towards the posterior end, and they narrow evenly towards the frontal pole. The temporal lobes are proportionately rather large and are marked off by a deep Sylvian fissure, which is the only sulcus to be seen on the lateral aspect. The olfactory elements are relatively reduced, as is characteristic of all primate brains.

Text-figure 1.



Lateral view of brain, showing the plane in which the serial sections were cut. $\times 2\frac{1}{2}$.

The *olfactory bulbs* project 1.75 mm. in front of the frontal pole of the cortex and are somewhat flattened from side to side. Their dimensions are as follows:—Length $4\frac{1}{2}$ mm., breadth 2 mm., height a little less than 3 mm.

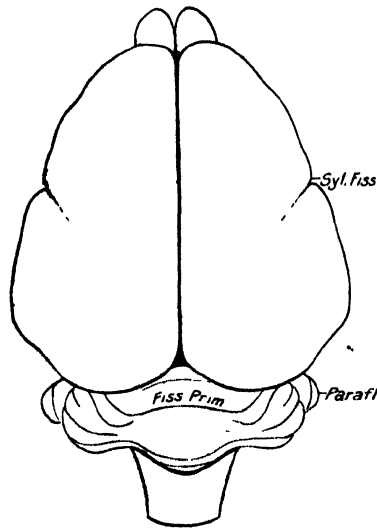
The cerebral hemispheres, apart from the bulbs, have the following dimensions:—Length 18 mm., total breadth 18 mm., height $11\frac{1}{2}$ mm. Viewed from the lateral aspect the hemisphere shows a pointed frontal pole, a blunt, rounded, occipital pole which lies in contact with the anterior surface of the cerebellum, but which does not project over it in the ordinary sense, and a plump dependent temporal pole. The temporal pole is marked off from the

rest of the temporal lobe by a vascular groove which, as shown by the sections, indicates the boundary between the piriform lobe below and the neopallium above. There is no true ectorhinal fissure. The cortex is smooth except for the conspicuous Sylvian sulcus, and this becomes flattened out below where the lateral olfactory tract passes over into the piriform lobe. The Sylvian sulcus, as may be seen by reference to Pls. II. & III., is formed mainly by the pseudo-sylvian fissure, but a small suprasylvian fissure also enters into its formation anteriorly.

From the dorsal aspect the Sylvian sulcus is also visible passing backwards and medially to within 5 mm. of the midline.

The medial aspect of the hemisphere shows a well-marked triradiate sulcus calcarinus which, as Elliot Smith has shown, is characteristic of the Primates. An examination of the structure of the cortex shows that the posterior limb of this complex, the retrocalcarine sulcus, is an axial sulcus in the striate area,

Text-figure 2.

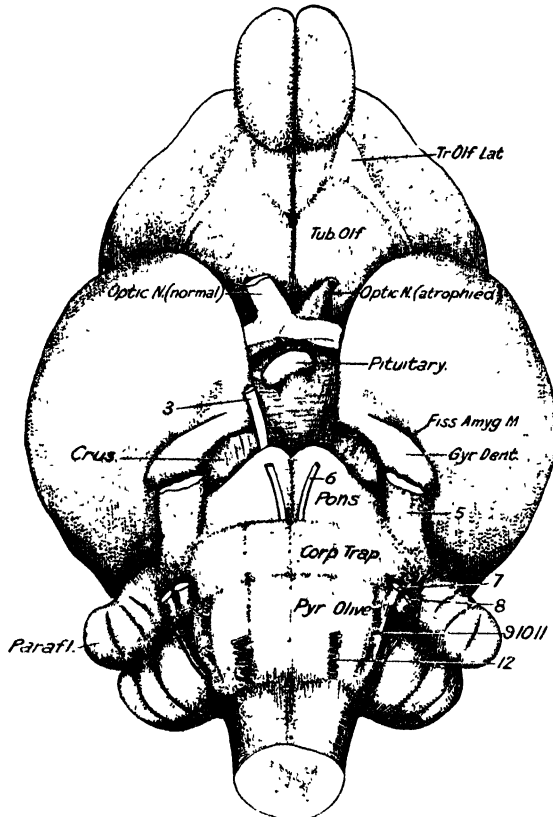


Dorsal view of brain. $\times 2\frac{1}{2}$.

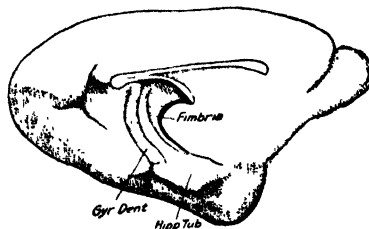
while the dorsal limb (S. paracalcarinus) and anterior limb (S. precalcarinus) are limiting sulci, separating the striate area from the limbic areas in front. The paracalcarine sulcus extends dorsally above the level of the corpus callosum, and at its upper extremity is inclined slightly forwards in a direction which indicates its relation to the intercalary sulcus found in the mammalia generally. These are the only true neopallial sulci to be seen on the medial surface of the hemisphere. The corpus callosum is long and attenuated, a characteristic feature of all Primates with the sole and significant exception of *Tarsius*. It measures 8.5 mm. in length, has a short thickened genu anteriorly, and a well-marked splenium posteriorly. The fornix is small, though the commissural portion seems to be better developed than in most Primate brains. The hippocampal formation is relatively conspicuous. The extraventricular alveus is as broad as the dentate gyrus and extends dorsally as far as the inferior aspect of the splenium. This is a primitive feature in which *Microcebus*

resembles the condition in insectivores such as *Tupaia*. A slight reduction in the extent of the extraventricular alveus is to be noted in *Chirogaleus*, especially at its lower extremity. In *Tarsius*, on the other hand, only the lower

Text-figure 3.

Basal view of brain. $\times 4$.

Text-figure 4.

Medial aspect of cerebral hemisphere. $\times 2\frac{1}{2}$.

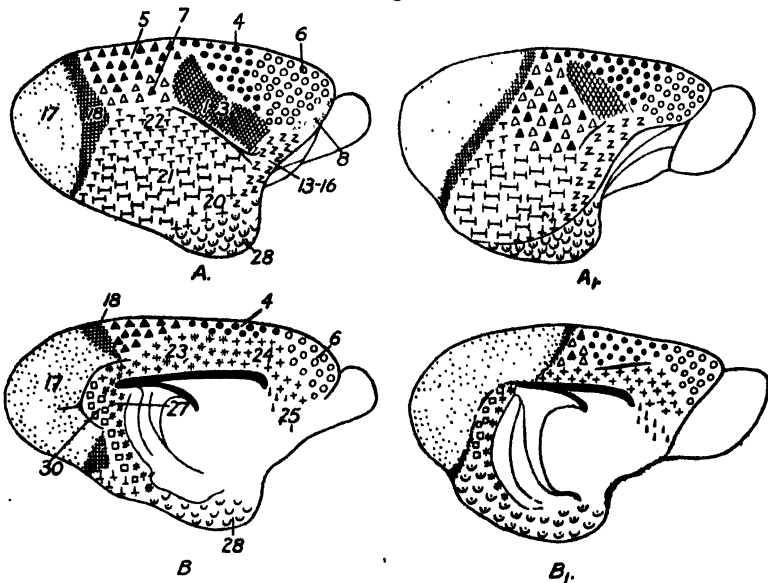
third of the hippocampus is exposed on the mesial surface of the hemisphere. In *Microcebus* the lower extremity of the hippocampal formation expands to form a relatively broad and flat hippocampal tubercle bounded medially by a

rounded border which is formed by a fringe of dentate gyrus. The dentate gyrus is an even regular band which above is kinked sharply beneath the splenium—the subsplenial flexure. Below, it shows a curious little kink which separates the main part of the gyrus from the hippocampal tubercle. The dentate formation, however, is continued round this notch into the medial border of the hippocampal tubercle. It is visible here on the ventral aspect of the brain, and, bounded laterally by a conspicuous *fissura amygdaloidea medialis*, it appears as a hook-shaped process directed postero-laterally and overlapping the proximal part of the crus cerebri. It thus bears a superficial resemblance to the uncus of the human brain, but, of course, represents only a portion of this structure. The ventral aspect of the brain shows the short olfactory peduncles and the white lateral olfactory tract. The olfactory tubercles are broad and flat, measuring 7 mm. antero-posteriorly and rather less than 6 mm. in transverse diameter.

HISTOLOGICAL LOCALIZATION OF THE CORTEX.

By reference to the serial sections it has been possible to plot out a number of areas on the surface of the neopallium which can be distinguished by their characteristic histological structure. An account is here given of these areas,

Text-figure 5.



Cortical areas of the brain of *Microcebus* (A and B) and *Tupaia minor* (A' and B'). $\times 2\frac{1}{2}$.

Brodmann's numbers are used. See references in text.

and their relative development and differentiation in comparison with other forms are briefly noted. The cortical areas in the brain of the Marmoset have been worked out by Brodmann (1), those of *Tarsius* by Woollard (19), and those of *Tupaia* by the writer (4). A diagram of the latter is here placed side by side with that of *Microcebus*. It may be noted that a further study of my preparations of the brain of *Tupaia* has enabled me, since my short paper in 1924,

to make a more detailed analysis of some of the main areas which I then described. Thus from the anterior part of the general parietal area of my previous communication I have been able to separate off an area post-centralis which is characterized by a more abundant development of the inner granule lamina. In the general temporal area I have been able to recognize three zones (corresponding to the superior, middle, and inferior temporal areas of other forms), and I have also been able to delineate an area retrolimbica agranularis.

Area Postcentralis (1-3). (Pls. I.-III.)

The cortex of this area is relatively broad and is characterized by a well-defined outer granular layer, an unusually narrow pyramidal layer, and a well-developed internal granular layer. In the latter the small granule-cells are closely packed, and in among them, apparently extending from the subjacent layer, are scattered rather large polygonal and rounded cells. Of the infra-granular layers the lamina ganglionaris is made up of somewhat scattered cells, mostly small pyramids, so that under the low power it forms a conspicuous clear band. The lamina multiformis is very broad and clearly separable into two layers, an outer, closely packed with medium-sized pyramids of even size, and an inner clear layer of irregular cells. In its structure this cortical area shows a very close approximation to the area postcentralis in *Lemur macaco* as described by Brodmann (1). It is also directly comparable with the corresponding area in brains of certain lower mammals, *e. g.*, the Mouse (*cf.* Tafel I in Rose's monograph on the histological localization of the cortex in small mammals (16)). In its surface extent this area in *Microcebus* forms a band of cortex extending obliquely downwards and forwards immediately in front of the Sylvian fissure, and reaching down to the insular area. Dorsally it does not appear to reach the dorso-medial margin of the cerebral hemisphere, and herein it differs from the corresponding area as it has been mapped out in the cortex of other Primates, and approximates to the condition found in the brains of small and more primitive mammals.

Area Preparietalis (5). (Pls. II.-VI.)

The preparietal area shows a particularly distinct lamination. The outer granular layer cannot be recognized as a definite layer, the pyramidal layer is broader than usual, the internal granular layer is broad and well defined, and the lamina ganglionaris is especially distinctive. The latter is formed of a regular row of medium-sized deeply staining pyramidal cells situated immediately deep to the lamina granularis interna. Among these cells, and very conspicuous under the high power, are scattered large pyramids, lightly stained. The presence of these large pyramids allows this area to be delimited with comparative ease from the post-central and parietal areas. Brodmann has described this area in *Lemur* and certain of the Anthropoidea, and has noted the superficial resemblance which it bears in its structure to the area gigantopyramidalis. Woollard (19) was unable to differentiate this area from the parietal area in *Tarsius*, and in most small mammals it appears to be likewise blended with adjacent areas. In *Microcebus* the preparietal area forms a relatively broad band of cortex extending over the dorsal aspect of the hemisphere from the sensori-motor areas in front to the occipital areas behind, and reaching over to the medial surface of the brain to a slight degree.

Area Parietalis (7). (Pls. IV. & V.)

This area is less extensive than the previous area and is situated between the latter and the temporal areas. The cortex is distinctly narrower than that of the preparietal area. The pyramidal layer is not so thick and the inner granular layer, though well developed, is not so sharply defined by reason of the fact that the closely packed granule-cells spread out into the adjacent laminae. The lamina ganglionaris is poorly defined, and the large pyramidal cells are completely absent from it: it is formed of small pyramids and diffusely scattered granule-cells. The deeper part of this layer is differentiated as a pale band under the low power, containing a relative paucity of cells. The multi-form layer is also divisible into two layers, of which the superficial consists of closely packed small pyramidal cells, and the deep of very small scattered cells.

Area Striata (17). (Pls. VI.-VIII.)

As is the case in all Primate brains, this area is the best differentiated of all the neopallial areas, and is especially characterized by the rich development of the inner granular layer. The lamina pyramidalis is of moderate width and contains an abundance of small pyramids with intermingled granular elements, while scattered here and there in the deeper layers are larger pyramids. The outer layer of the lamina granularis interna is represented by closely packed granule-cells situated in among the deeper cells of the pyramidal layer, and thus hardly distinct from the latter as a separate lamina except here and there. The inner subdivision of the fourth lamina forms a very distinct narrow band of cells outlined by the pale bands of the "stria of Gennari" and the inner line of Baillarger. Occasional large rounded and polygonal cells are to be found in all the layers of this lamina, and are relatively abundant. These large cells are probably the equivalent of the solitary cells of Meynert, and they are also present in the lamina ganglionaris, which is relatively poor in cellular content. The multiform lamina can be subdivided into two sharply defined layers, of which the superficial contains medium-sized pyramids closely packed, while the deep layer contains only scattered cells. This deep layer (6*b*) is absent from that part of the striate cortex which lines the walls of the calcarine fissure.

The area striata in *Microcebus* forms the occipital pole of the hemisphere, and extends for some way on to the lateral surface. On the medial aspect of the cerebrum it forms both sides of the retrocalcarine fissure and the caudal lips of the precalcarine and paracalcarine fissures. Everywhere the boundary between this and adjacent cortical areas is abrupt. In histological structure it corresponds well with the same type of cortex in *Lemur* as described and figured by Brodmann, but the inner layer of granules is much thinner. On the other hand, when compared with *Tarsius*, there are several marked differences. In the latter form the inner granular layer is much more differentiated and, as described and figured by Woollard (19), shows peculiar features which indicate for it a special position among the types of striate cortex to be found among the Primates. The interesting point in regard to the visual cortex of *Tarsius* is that it is almost identical in structure with that of *Cebus* (figured by Mayer (12)), in which the lamination is even more differentiated than in the Old World Monkeys. It seems, indeed, that the layer of granules described as the outer layer of the lamina granularis interna in *Tarsius* by Woollard corresponds to the layer IV. *b* in *Cebus*, the layer IV. *a* being represented in *Tarsius* by a layer of granules among the more deeply

situated cells of the pyramidal layer. This latter layer is quite distinct in some sections of the visual cortex in *Tarsius*. In *Tupaia* (4) the area striata is as distinctive as it is in *Microcebus*, but in this insectivore there is only one distinct layer of granules, which here and there shows a tendency to become delaminated into two layers. The area in *Tupaia* at first sight (see the charts in text-fig. 5) seems to be more extensive than in *Microcebus*, reaching forward almost to the area giganto-pyramidalis, and, on the mesial surface of the brain, as far down as the corpus callosum. But in the Mouse-lemur the visual cortex has been pushed back by the greater development of the parietal areas, and has been accommodated in the deep calcarine fissure only a portion of which is represented in the brain of the Tree-shrew.

Area Occipitalis (18). (Pls. VI.-VIII.)

This cortical area, which forms a zone surrounding the striate area especially on the lateral aspect of the hemisphere, is distinguished by a relatively broad pyramidal layer containing a regular arrangement of pyramidal cells less closely packed than in the parietal area. The inner granular lamina is well defined and of moderate width. The lamina ganglionaris contains rather large scattered pyramids which extend in among the deeper cells of the inner granular layer. It was not found possible to distinguish a preoccipital area, as has been done by Brodmann in *Lemur*. The band of cortex formed by the occipital area is broader than in *Tupaia*, but does not reach the extent shown for it in *Tarsius* by Woollard.

Area Temporalis Superior (22). (Pls. III.-VII.)

The temporal areas can be distinguished from the neighbouring parietal areas partly by the density of cells in the superficial parts of laminae V. and VI. which form characteristic dark bands when the sections are viewed under the low power. In the superior temporal area the outer granular layer is hardly distinct, the pyramidal layer is of moderate width, the inner granular layer is moderately developed and consists of rather loosely packed cells. In the lamina ganglionaris, immediately deep to the inner granular layer, are abundant small and medium-sized pyramids, and beneath this a relatively acellular layer which forms a pale band under the low power. The multiform lamina is thin and divided into two layers, a superficial with closely arranged small pyramidal and polygonal cells, and a deeper stratum with fewer cells, most of them flattened, with their long axes lying horizontally.

Area Temporalis Media (21). (Pls. II.-VIII.)

This area is differentiated from the previous area by a better defined external granular layer, a narrower lamina pyramidalis, and by a pronounced development of the inner granular layer. This is broad and rich in small granule-cells, but it is not sharply defined from the pyramidal layer immediately superficial to it. The lamina ganglionaris is narrower and denser, while the lamina multiformis shows a tendency to the differentiation of a third layer consisting of a narrow band of flattened cells in contact with the subcortical white matter.

Area Temporalis Inferior (20). (Pls. V.-VII.)

This cortical area is of small extent and forms a transition between the middle temporal and piriform areas. The outer granular layer is particularly well defined, the pyramidal layer is very narrow, while the inner granular layer is but feebly developed.

Of the three temporal areas thus demarcated the middle area has the most distinctive structure and is conspicuous for the marked development of the internal granular lamina. The areas occupy all that part of the cerebral hemisphere which can be called the temporal lobe except for its tip, which is formed by piriform cortex. Compared with *Tupaia* the areas are much better defined and more extensive. They are apparently also more extensive than the corresponding areas plotted out by Woollard for *Tarsius*.

Area Precentralis or Gigantopyramidalis (4). (Pl. I.)

This area is composed of rather broad cortex and characterized especially by the presence of conspicuous large pyramids in the ganglionic lamina. The external granular layer can hardly be defined, and the pyramidal layer is of average breadth. The inner granular layer is not distinctly differentiated, but there are numerous scattered cells of the granular type intermingled with the more deeply situated cells of the pyramidal layer, and which might be interpreted as a lamina granularis interna. It is not possible, therefore, to affirm that this cortical area is agranular, a character which in the brains of higher Primates is regarded as distinctive of it. Woollard describes an indefinite stratum of small granules in the precentral area of *Tarsius*, and this granular nature of the area may be regarded as a primitive feature. In lamina V. are numerous large and well-staining pyramidal cells, arranged not in definite rows as in the prepirietal area, but scattered evenly throughout the thickness of this lamina. The multiform lamina is of moderate width, and is composed of small pyramids fairly closely packed. This lamina is not divisible into subsidiary layers, as is the case with the adjacent postsensory area. There is a tendency for this lamina to pass gradually into the subjacent white matter. The postcentral area is most easily defined along the dorso-medial border of the hemisphere, and here the cortex is more definitely agranular.

Area Frontalis Agranularis (6). (Pl. I. fig. 1.)

Here the cortex is broader than usual. The pyramidal layer is broad and contains an abundance of small pyramids. The inner granular lamina cannot be recognized as a definite layer, and there is an absence of large pyramids in the infragranular layers. This area extends from the precentral area as far forwards as the frontal pole of the hemisphere. Its distinctive features cannot be seen in the section illustrated in Pl. I. because this section has been cut somewhat obliquely through the cortex. Compared with *Tarsius* this cortical area in *Microcebus* seems to be of much the same extent. It shows an expansion compared with the cortex of *Tupaia*, but this expansion is not so notable as in the case of the parietal and temporal areas.

Area Frontalis Granularis (8).

If the insular area is traced forwards beyond the limit of the claustrum it is continued straight on towards the frontal pole as a strip of cortex which has (except for the absence of the claustrum) much the same structural features as the insular area. This is evidently the equivalent of Brodmann's granular frontal area. Compared with the previous area the pyramidal layer is thinner, and there is a fairly well-defined though narrow inner granular lamina. The lamina ganglionaris contains rather closely packed medium sized pyramids. The granular frontal cortex is but little differentiated in this brain, and its surface extent seems to be as small as in *Tarsius*. In the larger Lemurs

(Brodmann) it is much more extensive and reaches on to the medial surface of the cerebral hemisphere. In *Tupaia* it is not evident unless it be represented by the rostral end of the insular area. In the brains of the small mammals investigated by Rose there was likewise no true granular frontal cortex to be found, the area 8 which he describes in the Mouse not being homologous with the area of the same number in Primates. Brodmann (2) further notes that the area 8 of Lemur cannot be certainly homologized with area 8 of the *Cercopithecinae*.

Area Insularis (13-16). (Pls. I.-IV.)

The surface extent of this area corresponds to that of the claustrum, which appears to be delaminated from the deep aspect of the lamina multiformis. The histological features of this cortical area vary somewhat in different parts of its extent, but on the whole it is characterized by a well differentiated external granular layer, a very narrow pyramidal layer, a well developed inner granular lamina which is almost as thick as the pyramidal layer, an indistinct lamina ganglionaris containing only small cells and hardly to be differentiated from the superficial part of the lamina multiformis, and, above all, the delamination from the latter lamina of the claustrum. The insular area forms the floor of the ventral part of the Sylvian fissure. Except for the criterion of the claustrum it would be a difficult matter to determine the precise limits of the area, especially rostrally, where it passes insensibly into the frontal areas. This gradual transition to the frontal areas is also noted by Woollard for *Tarsius*.

Area Pregenualis (25). (Pl. I. fig. 1.)

Here the lamination is generally indistinct. There is no internal granular lamina and laminae III. and V. grade into each other, being formed of small rounded pyramids. The multiform lamina is very narrow.

Area Limbica Anterior (24). (Pl. I.)

The outer granular layer is represented by a slight condensation of small pyramidal cells, the pyramidal layer is narrow, the inner granular layer is hardly represented as a definite layer, the lamina ganglionaris is formed of numerous medium sized rather rounded pyramids closely packed together, and the multiform lamina is made up of small cells and shows a sharp boundary line with the subcortical white matter.

Area Limbica Posterior (23). (Pls. II.-V.)

This area is chiefly to be distinguished from the previous area by the presence in it of a fairly well-defined inner granular lamina, which under the low power appears as a pale band. The area extends further forwards above the corpus callosum, at the expense of the anterior limbic area, than it does in *Lemur*, and much further forward than in *Tarsius*, in which it appears to be much reduced. It may be noted also that in *Tupaia* the whole of the limbic area is agranular, and so would presumably correspond to area 24 of Brodmann. In this insectivore, as has been pointed out before, the limbic area is much reduced in extent by the downward extension of the visual area on the medial surface of the hemisphere to the corpus callosum.

Area Presubicularis (27). (Pls. VI. & VII.)

This narrow strip of cortex shows the usual characteristic features, the second, third, and fourth laminae being fused together and composed of very

small cells closely packed. The ganglionic lamina is represented by a pale band with very few and scattered cells, while the lamina multiformis is a narrow layer of small rounded and lightly staining cells. The whole cortex is very thin and extends down the caudal margin of the hippocampal fissure. It corresponds precisely in its structure to the homologous cortex in the brains of other Primates, and, indeed, of most other mammals.

Area Retro-limbica Agranularis (30). (Pl. VII.)

This is again a narrow band of cortex which lies immediately caudal to the previous area, and is distinguished by the fact that the internal granular layer is entirely absent.

GENERAL CONSIDERATIONS OF THE CORTICAL AREAS.

A general survey of the cortical areas in *Microcebus*, by reference to the microphotographs and the charts here produced (text-fig. 5), indicates a grade of differentiation considerably more pronounced than in non-primate brains of equivalent size. In comparison with *Tupaia* the temporal areas show a great increase in size. An expansion is also to be noted in the frontal and parietal regions. In the latter it is possible to differentiate an area preparietalis from the area parietalis, while in the former an indication of a granular frontal area is noted. The differences in regard to the striate area and pyriform lobe are not so obvious at first sight. The area striata in *Microcebus*, however, has to a large extent become accommodated within the lips of a very deep calcarine sulcus, and so is not all visible from the surface. In *Tupaia* the calcarine sulcus is only just indicated and the visual cortex is practically fully exposed on the surface, appearing, therefore, to occupy a relatively greater area. In this insectivore its forward extent on the medial surface of the hemisphere has encroached on the limbic areas to a remarkable degree. This unusual and, indeed, unique disposition may be regarded as a generic specialization, for it is not present in *Ptilocercus* (5), another genus of the Tupaiidae.

On the other hand, in *Tupaia* the pyriform cortex is partly accommodated in the ventral lip of the ectorhinal fissure, this fissure being hardly represented in *Microcebus*.

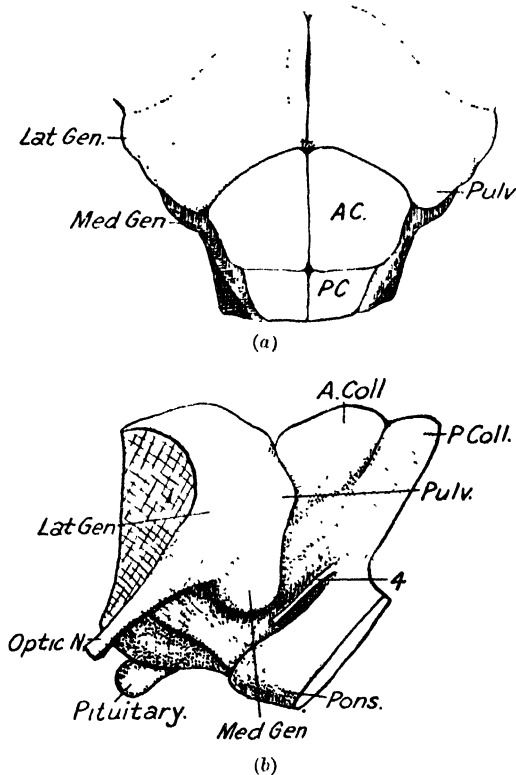
THE THALAMUS.

The dorsal and lateral views of the thalamus are shown in text-figure 6, *a* & *b*. From these it will be seen that the thalamus is small relatively to the mid-brain, but it is much broader than the superior colliculi, and herein resembles the thalamus in other small members of the Primates, and shows a marked difference from the rounded thalamus of insectivores of comparable size. This increased breadth is associated with the greater development of the lateral nuclei.

The stria medullaris is relatively narrow, indicating a reduction of the habenular elements of the thalamus. A feeble depression marks off the small posterior pole of the thalamus, which represents the pulvinar of higher forms. Laterally the outline of the lateral geniculate body is faintly indicated, and passing upwards and backwards to reach its ventral pole is the optic tract. The external dimensions of the lateral geniculate body (checked by reference to the microphotographs) are as follows:—vertical diameter 2.5 mm., antero-posterior diameter 1.8 mm. The medial geniculate body is much more conspicuous, forming a prominent and circumscribed tubercle projecting down on the lateral aspect of the crus cerebri.

The structure of the thalamus of *Microcebus*, so far as its cytoarchitecture is concerned, has been studied from the transverse serial sections prepared. A brief account will be given of the main nuclear masses for comparison with those of other Primates and of insectivores. It will be seen that this primitive brain, like that of *Tarsius* (7), provides a morphological link through which the thalamus of higher Primates (including Man) may be more accurately compared with that of primitive mammals. For purposes of description the thalamus proper may be divided into anterior, lateral, ventral, and medial nuclei, nuclei related to the optic tract (including the lateral geniculate body), and the medial geniculate body. In order to give an adequate idea of the relative

Text-figure 6.

Thalamus. (a) Dorsal view; (b) Lateral view. $\times 5$.

extent of the thalamic elements reference is frequently made to the section numbers, and the significance of these will be appreciated if it is noted that the thalamus in the serial sections prepared is taken to extend from section 328 (which lies at the level of the rostral margin of the anterior nucleus) to section 580 (which represents the level of the caudal margin of the medial geniculate body).

The Anterior Nuclei.—The elements of this group first appear in section 328 rostrally. By section 336 they have assumed their characteristic proportions and disposition (Pl. III.). The antero-dorsal nucleus is composed of cells which are somewhat smaller than those of the other elements, but, being deeply stained and closely packed, they are much more conspicuous. A few

sections caudal to 336 (at which level the nucleus shows its maximum development in cross-section) the medial angle of the nucleus becomes continuous with a commissural nucleus of small cells which runs ventral to the nucleus paratænialis and crosses the mid-line. By section 355 the antero-dorsal nucleus has disappeared and is now replaced by the main part of the lateral nucleus.

The antero-ventral and antero-medial nuclei are only indistinctly separated from each other in occasional sections (as, for instance, in the section figured in Pl. III.) by fasciculi of the superior thalamic radiations which are coursing dorso-medially. They form a relatively large group of medium-sized cells extending from the antero-dorsal nucleus dorso-laterally as far as the mid-line. The nuclei of both sides thus form together a broad U with a dorsal concavity in which lie the paratænial nucleus and the dorsal paraventricular nucleus. Caudally the antero-medial nucleus abuts against the nucleus rhomboideus of the mid-line, and here seems to correspond to at least a part of the nucleus submedius as described in higher Primates (13, 22), Carnivora (14), etc. On the other hand, there is little doubt that it is homologous with the antero-medial nucleus of lower forms (Rodents, Insectivora). There is certainly no other element in the thalamus of *Microcebus* which can be termed the nucleus submedius. In a previous paper on the thalamus of *Tarsius* (7) the suggestion was made that the nucleus submedius of higher forms corresponds in part to the antero-medial nucleus of lower forms, and the present study seems to confirm this. The antero-medial nucleus extends as far caudally as section 362, while the antero-ventral nucleus reaches to section 368.

The elements of the anterior nucleus of *Microcebus* in their relative development are closely comparable with those of *Tupaia*. In *Tarsius* the antero-dorsal nucleus is somewhat smaller and the antero-ventral nucleus is more sharply encapsuled and circumscribed. In the latter feature *Tarsius* shows a higher grade of development.

The *Lateral Nuclei* may be subdivided into a principal part of the lateral nucleus and a pars posterior or pulvinar.

The main nucleus commences rostrally where the antero-dorsal nucleus comes to an end in section 355, and here it forms a cap over the caudal part of the antero-ventral nucleus, producing an elevation on the dorsal surface of the thalamus which corresponds to a part of what in descriptive anatomy is termed the anterior tubercle of the thalamus. The nucleus is composed of cells similar in type to those of the antero-ventral nucleus, but they are less closely packed. The nucleus expands in a caudal direction and reaches its maximum development in transverse section at about section 410 (Pl. IV.). Here it lies between the dorso-medial nucleus medially, the ventral nucleus ventrally, and the reticular nucleus laterally. More caudally (Pl. V.) the dorsal part of the main nucleus becomes differentiated to form the pulvinar. By section 490 (Pl. VI.) the main part of the lateral nucleus has become reduced to a small and indistinct group of cells lying in the angle between the pulvinar, the large-celled nucleus of the optic tract, and the medial geniculate body. From here it sends an extension towards the medial geniculate body which represents the nucleus suprageniculatus of higher Primates. This nucleus, however, is by no means so conspicuous and well defined as it is in *Tarsius*. In relative size the main part of the lateral nucleus of *Microcebus* approximates to that of *Tarsius*. In comparison with the thalamus of *Tupaia* (8), on the other hand, it shows a significant expansion, and it is this increase in size which is mainly responsible for the breadth of the dorsal surface of the thalamus and the caudal displacement of the pulvinar which is so characteristic in the small Primates when compared with the Insectivora. In *Tupaia*

the main part of the lateral nucleus is hardly larger than the anterior nuclei, and its free surface is limited to the anterior third of the dorsal surface of the thalamus.

The *Pulvinar* or pars posterior of the lateral nucleus appears rostrally at about section 460 (Pl. V.) as a differentiation from the dorsal part of the lateral nucleus, which extends laterally to make contact with the oral extremity of the lateral geniculate body. At first to be distinguished from the main part of the lateral nucleus by a relative condensation of its constituent cells, as it expands caudally the pulvinar becomes separated from it by cortico-tectal fibres which run between the tectum and the internal capsule. The maximum development of the pulvinar in cross-section is shown in Pl. VI., which corresponds to section 490. Caudal to this level it becomes gradually smaller, and finally disappears at section 536, forming at its posterior extremity a small projecting pole. The pulvinar is not so large relatively as in *Tarsius*, nor does it show the same degree of internal differentiation. In *Tupaia* the representative of the pulvinar is almost as extensive as it is in *Microcebus*, but it occupies a more dorsal and rostral position by reason of the fact that it has not been displaced by the main part of the lateral nucleus. If this interpretation is correct, it may be inferred that the transition from the insectivore to the Primate type of thalamus is not so much associated with a relative increase in the size of the pulvinar as with that of the main part of the lateral nucleus.

The *Lateral Geniculate Body* is large and highly differentiated. In conformity with the general mammalian type it consists of a dorsal and a ventral nucleus. The latter is relatively very small and is only to be seen in the more rostral sections (Pl. V.). The dorsal nucleus reaches its maximum size in cross-section at about section 490 (Pl. VI.). Here it can be seen to consist of a series of six concentrically arranged cell laminae separated by well-defined medullary laminae. The outer cell lamina is very thin and contains only small cells. The second lamina consists of large deeply staining cells. Then follows a lamina of medium-sized cells, while the medial three laminae are made up of quite small granular cells. It is this latter small-celled element of the dorsal nucleus which seems to have been mistaken by Woollard & Beattie (21) for a highly organized and laminated ventral nucleus of a type which they regarded as a specialization characteristic of the Lemuroidea. However, even if the interpretation of these authors is erroneous, it may be argued that the small-celled element of the dorsal nucleus attains to a development in the Lemuroidea which renders it difficult to suppose that the typical lemuroid lateral geniculate body could have given rise to that which is characteristic of the Anthropoidea. A more significant difference between the lateral geniculate body of the Lemuroidea and Anthropoidea is seen in the manner in which the laminae have become folded. Whereas in the Lemurs there is a tendency for the laminae to become folded so as to form a medial concavity or hilum from which the optic radiations stream out, in the Anthropoidea the laminae tend to become folded in the opposite direction, so that in this suborder the surface from which the optic radiations emerge is partly or wholly convex, while a hilum is produced ventrally in the region where the optic tract enters. In the elaboration of the lateral geniculate body in these two suborders, therefore, two opposing lines of development seem to have been followed, and it may perhaps be assumed therefore that the Lemuroidea and the Anthropoidea are to be regarded as two divergent groups which could only have been derived from a prosimian ancestor of very primitive form. In regard to the evidence to be gained from the study of the lateral geniculate body in assessing the affinities of the Primates, it is to be noted that in the Anthropoidea alone the nucleus shows great variations,

As Kornyei (11) has pointed out, it reaches a higher grade of development in respect of the folding of its laminae in monkeys generally than in the anthropoid apes and even Man himself, while in the Orang its structure is astonishingly simple. The position of *Tarsius* in this connection is also difficult to interpret. Attention has been called by Ziehen (23) and Woollard to the resemblance which the lateral geniculate body of this animal shows to the anthropoid type. In a recent paper (7) the present author also noted this resemblance, with special reference to the mode of entry of the optic tract fibres. But the geniculate body of *Tarsius* exhibits peculiarities of its own. In comparison with the condition in *Chirogaleus* and *Microcebus*, it is rotated on a vertical axis through almost 90° , so that the optic radiations emerge from a hilum which opens anteriorly instead of medially. This rotation, indeed, has produced in frontal sections a resemblance to the anthropoid type of lateral geniculate body which in some ways is spurious. Further, there is no definite magnocellular element such as is found in other Primates. If these aberrant features in the structure of the lateral geniculate body in *Tarsius spectrum* are to be regarded as a tarsioïd specialization (i. e., characteristic of the suborder), the Tarsioidea can hardly be considered as representative of a group from which the Anthropeidea have been derived. On the contrary, a comparative study confined to this nucleus leads to the supposition that *Tarsius* represents the end product of a line of evolution which parallels in many respects the development of the higher Primates, but does not really approximate to them.

Large-celled Nucleus of the Optic Tract (Cajal's nucleus of the mesencephalic root of the optic tract).—This nucleus, which forms one of the terminal nuclei of the fibres of the optic tract, first appears rostrally at section 434 as a group of large, polygonal, and deeply staining cells at the dorsal aspect of the thalamus between the lateral nucleus and the pretectal nucleus. More caudally (Pl. V.) it extends as a band of cells from the optic tract around the lateral margin of the pretectal nucleus. By section 490 (Pl. VII.) the nucleus has become reduced to a small group of cells extending between the caudal parts of the pretectal and principal lateral nuclei. This nucleus is not so well developed, especially in its caudal extension, as in *Tarsius*. In insectivores in which the optic tract is large (e. g., *Tupaia* and *Macroscelides*) the nucleus is a relatively important element. In the ascending scale of the Primates it becomes progressively reduced and appears to become incorporated in a strand of cells which has been termed the nucleus limitans (13, 22).

The Pretectal Nucleus is first seen rostrally at section 454, and it forms a rounded group of small, closely packed, fusiform, and lightly staining cells. It is penetrated by numerous bundles of fibres. As may be seen in Pl. V. this nucleus is intimately related to the upper end of the optic tract, and fibres from the tract penetrate into it. It is almost certain, however, that these fibres are not retinal fibres. At least in my Marchi preparations of the rat's brain, in which the optic nerve has been cut, only a few discrete black granules can be found at the outer margin of the pretectal nucleus, and this nucleus in the rat is very well developed.

Centre Median Nucleus.—It has previously been pointed out (7) that this nucleus, which is so conspicuous in higher mammals, is represented in lower mammals by a group of cells which has been included by some authors in the lateral part of the nucleus parafascicularis. This interpretation has recently been corroborated by Rioch (15). The centre median nucleus in *Microcebus* is shown in Pl. V. It is not so sharply circumscribed by a medullary capsule as in *Tarsius*. That this group of cells really corresponds to the large and well-defined centre median of the large Lemurs, e. g., *Lemur macaco*, is sufficiently

indicated by a study of the thalamus of *Chirogaleus*. In this form the centre median nucleus, in respect of relative size and definition, represents an intermediate stage between *Microcebus* and *Lemur*. It may be noted that the centre median is also present in *Tupaia*, but is still less well defined than in *Microcebus*.

The Ventral Nucleus.—This nucleus is well defined, consisting of fairly deeply staining and rather large cells which tend to arrange themselves in a reticulated formation among the entering fibres of the medial fillet. It extends from section 353, where it is situated immediately ventral to the caudal part of the antero-ventral nucleus, to section 484, where it becomes indistinct and replaced laterally by the medial geniculate body. It is not possible on the basis of the sections available to subdivide the ventral nucleus into component parts: indeed, the nucleus appears to be remarkably simple in *Microcebus*.

Medial Geniculate Body.—This nucleus extends antero-posteriorly from section 484 to section 580. As in *Tarsius*, higher Primates, and, indeed, most mammals, three elements can be recognized in it: there is a central area of small cells, a dorso-lateral element of larger and more deeply staining cells, and a small caudo-ventral group of very small scattered cells. The lateral fillet seems to be most closely related to the central group. In *Tarsius* the large-celled component was found to be directly continuous with the nucleus suprageniculatus. In *Microcebus* this connection is not clear.

CORPUS STRIATUM.

There is little that need be noted in connection with these basal ganglia. The caudate nucleus and lenticular nucleus are well separated from each other by the internal capsule, though anteriorly (Pl. I. fig. 2) they are connected by a few strands of grey matter. Woollard (20) notes that "*Tarsius* shows a primitive aspect of cerebral organization in the fact that the caudate nucleus and putamen are fused over a very large area." Such is not the case in *Microcebus*. The claustrum, putamen, and globus pallidus are well differentiated. There is a distinct entopeduncular nucleus which can be recognized most rostrally at section 370, where it comes up against the medial aspect of the globus pallidus. It does not appear, however, to become continuous with this element, and its cells, moreover, are much smaller. Caudally this group of cells becomes flattened out between the ventral aspect of the pes pedunculi and the optic tract, and here seems to correspond in position to Cajal's nucleus of the optic tract*. Finally, at section 428 the entopeduncular nucleus disappears. The amygdaloid complex is well differentiated, and its component elements, the medial, central, large-celled basal, lateral, and cortical nuclei may be readily distinguished (Pls. IV. & V.).

THE CEREBELLUM.

The cerebellum of *Microcebus* is remarkably simple and is only slightly more elaborated than that of *Tarsius*, principally in regard to the middle lobe. The anterior surface is in contact above with the cerebral hemisphere, but the occipital pole of the latter does not extend as far back as the fissura prima. In other words, the cerebellum is hardly at all overlapped dorsally by the cerebrum.

The cerebellum as a whole is 6.5 mm. in vertical diameter, 7 mm. in antero-posterior diameter, and just over 13 mm. in greatest width (between the para-flocculi). The two main fissures, fissura prima and fissura secunda (Elliot Smith's

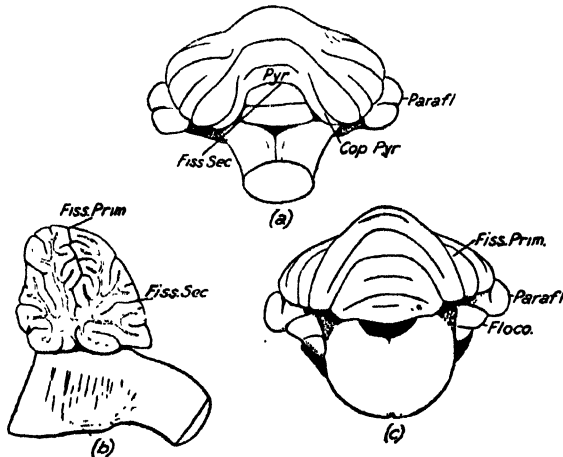
* This is to be distinguished from Cajal's "Nucleus of the Mesencephalic Root of the Optic Tract."

terminology) can readily be recognized by reference to the sagittal section. The anterior lobe is limited above and caudally by the large U-shaped fissura prima, and is itself divided into two main lobules of approximately equal size, the central lobe and the culmen. Of these the former is subdivided into four transverse folia by three incomplete fissures, and the latter into three folia by two incomplete fissures. The sagittal section shows a small folium immediately anterior to the "hilum" of the cerebellum which represents the lingula. The posterior lobe consists of uvula and nodule, the former being subdivided by a complete transverse fissure into two folia, and the latter is buried on the ventral aspect of the cerebellum in close contact with the dorsal surface of the medulla.

The paraflocculus, connected with the pyramid by a distinct unfissured copula pyramidis, consists of two main folia, and at its base can be recognized a small flocculus divided into three folia.

The median part of the lobus medius is crossed superficially by two transverse fissures only, and thus appears remarkably simple. The prepyramidal fissure

Text-figure 7.

Cerebellum. (a) Posterior aspect; (b) Sagittal section; (c) Anterior aspect. $\times 2\frac{1}{2}$.

(fissura secunda of Ingvar) does not extend into the lateral lobe, and, as seen in the sagittal section, is very shallow. Above this is a complete fissure, which is deeper and extends laterally to become continuous with a fissure on the lateral lobe. Dorsal to this, again, a distinct area medullaris may be seen running from the vermis to the lateral lobe (indicated in the diagrams by dotted lines). The lateral lobes of the cerebellum are small in proportion to the vermis, and are subdivided by five fissures of which only one becomes continuous with a fissure across the vermis.

A comparison with Woollard's figures of the cerebellum of *Tarsius* (18) shows that the chief difference between these two forms is the slightly more elaborated condition of the lateral part of the middle lobe in *Microcebus*. It should be noted that there is no lobus paramedianus in *Microcebus*. Woollard (20) quotes Bolk to the effect that this lobe is present in the cerebellum of all Lemurs, and, since this lobe is absent in *Tarsius* and New-World Monkeys, he infers that, so far as the cerebellum is concerned, "the New-World Monkeys

resemble *Tarsius* more closely than any member of the order Lemuroidea." Since the lobe is absent in *Microcebus*, this argument can no longer hold.

It may be noted that in some respects the cerebellum of *Microcebus* is more simple than it is in *Tupaia* (4). In the latter not only are the measurements of the cerebellum larger (though the weight of the brain as a whole is less), but the lateral lobes show a more extensive fissuration. On the other hand, the anterior lobe is smaller in bulk, being hollowed out rostrally to a considerable extent by the huge anterior colliculus.

DISCUSSION.

The brain of *Microcebus* is the most primitive known brain of the Lemuroidea and, in many respects, of the Primates as a whole. From a consideration of this brain and of the brain of *Tarsius* (which is also remarkably primitive) it is possible to gain some conception of the status (as regards cerebral evolution at least) of the ancestral form from which the existing order of the Primates has been derived, and of the common progenitor from which the three suborders of this group—Lemuroidea, Tarsiodea, and Anthropeidea—have diverged.

We may postulate the following features of the brain of such a form. The cerebral cortex must have been devoid of sulci except for the calcarine, hippocampal, and ectorrhinal fissures, and perhaps an indication of the suprasylvian fissure. It may be noted in this connection that a true Sylvian fissure of the Primate type is not developed in *Tarsius*, though a pseudosylvian sulcus and an occasional representative of the suprasylvian fissure are present. The hippocampal and ectorrhinal fissures are common features in the brains of primitive mammals, but it is probable that in the hypothetical early Primate here under consideration the ectorrhinal fissure had become reduced to little more than a vascular groove.

Although the triradial form of calcarine fissure is characteristic of many Primates, in some of the most primitive members of this group, e. g., *Hapale*, the dorsal limb is not developed. It may be said, however, that a distinct retrocalcarine element, an axial sulcus in the area striata, is a distinguishing and constant feature of all Primate brains, and, indeed, found in no other mammalian forms. This significant fact has been pointed out by Elliot Smith (10). This author has further emphasized the fact that the retrocalcarine sulcus is one of the most striking cerebral characteristics which link up the Lemuroidea with the Anthropeidea, and it supplies a cogent argument for those who believe that these two groups are sufficiently closely related to be included in the single order of Primates. The precalcarine element, on the other hand, is a common mammalian sulcus.

From these considerations it appears that the fissuration of the cerebral cortex of the common ancestor of the three suborders of the Primates must have been still more primitive than that of *Microcebus*. In some ways, indeed, it was presumably more primitive than *Tupaia*, for in the latter, besides a definite representative of the suprasylvian sulcus, there is a short callosomarginal sulcus. On the other hand, there is no suggestion in *Tupaia* of a retrocalcarine sulcus, and the precalcarine element is only just indicated.

As regards the structure of the cortex and the differentiation of the cortical areas, the following points call for note. A characteristic feature of all Primate brains is the extent and elaboration of the visual cortex or area striata. This is also the case in the brains of *Microcebus* and *Tarsius*. In the latter, however, the degree of lamination of the visual cortex has proceeded further than is the case in Lemurs, and even in many of the Anthropeidea. Here, it seems evident, the element of parallelism has played a part. In *Tupaia* the differentiation and

extent of the area striata recalls the characteristic Primate condition, but in this insectivore, instead of being accommodated in a retrocalcarine sulcus, the area has pushed forwards and downwards to the upper surface of the corpus callosum at the expense of the limbic areas. This unusual disposition would presumably have been avoided in the ancestral Primate form by the development of the retrocalcarine sulcus.

Further characteristics of the cortex of an ancestral type of Primate would have been (1) a "motor" area which had not yet become completely agranular as it is in higher Primates, (2) a parietal area from which the preparietal area had not differentiated (these areas are not to be distinguished from each other in *Tarsius*), (3) an indication of a granular frontal area of very slight extent, and (4) the appearance of a considerable part of the piriform cortex on the lateral surface of the cerebral hemisphere (as in both *Tarsius* and *Microcebus*). In the extent and differentiation of the frontal, parietal, and temporal areas the brain of this primitive form probably showed a distinct advance upon the condition found in *Tupaia*, though it presumably had itself been derived from a brain with cortical areas of very similar proportions and differentiation.

The cerebral commissures of *Tarsius*, as pointed out by Elliot Smith, are remarkably primitive, and resemble closely these structures in some of the most primitive insectivores. It can only be concluded that the commissures (corpus callosum and ventral commissure) in the ancestral Primate must have been almost as primitive as in a form such as *Erinaceus*, and much more primitive therefore than in *Microcebus* or even *Tupaia*. The olfactory apparatus as a whole no doubt showed a considerable reduction, but presumably this reduction had not proceeded further than is the case with *Microcebus*, in which the olfactory bulbs and secondary centres are rather larger proportionately than in other Primates. Such a reduction appears to be foreshadowed in *Tupaia*, in which these parts of the brain are smaller than in other insectivores. The gradual and progressive reduction of the olfactory centres of the brain is well exemplified in the series *Erinaceus*, *Ptilocercus*, *Tupaia*, *Microcebus*, and *Tarsius*. In the complete exposure of the extraventricular alveus in *Microcebus*, from the level of the subsplenic flexure to the hippocampal tubercle, this form resembles the condition in insectivores generally. In *Chirogaleus* the extraventricular alveus shows a slight reduction, and this reduction has proceeded still further in *Tarsius*.

The optic thalamus of the ancestral Primate was probably to be distinguished from that of non-primates of equivalent size by the development of the lateral nuclei (main part and pulvinar), which had led to a marked increase in the breadth of its dorsal moiety. The pulvinar, associated mainly with the occipital regions of the cerebral cortex, showed little advance on the stage of development which it has reached in *Tupaia* except that it had become pushed caudally to form a projecting pole. On the other hand, the main part of the lateral nucleus (possibly related functionally with the so-called association areas of the cortex) had increased very considerably as compared with *Tupaia*. The lateral geniculate body would have shown a well laminated dorsal nucleus and a considerable reduction of the ventral nucleus, a condition a little in advance of that in *Tupaia*. The dorsal nucleus would be rather on the lateral than the basal aspect of the thalamus, and the folding of its laminae must presumably have been very slight. In this connection it may be noted that in *Microcebus* the degree of convolution of this nucleus is limited to a curving of the laminae as a whole, in conformity with the convex lateral surface of the thalamus, and even in the Orang the dorsal nucleus of the lateral geniculate body retains its primitive simplicity as regards its convolutions,

its laminae being flattened. In the majority of the Primates, on the other hand, the laminae of this nucleus have become folded to a greater or lesser degree of complexity. In this further development there appear to have been two diverging tendencies in the Lemuroidea and the Anthropeidea. One line of development, represented by the Lemuroidea, was associated with an inward folding of the laminae, so as to form a medio-dorsally directed "hilum" from which the optic radiations emerge, and with this folding there was a great increase in the small-celled elements of the nucleus. The other line of development, represented by the Anthropeidea, was associated with an outward folding of the laminae, so as to produce a medio-ventrally directed "hilum" related to the termination of the optic tract (the optic radiations emerging dorsally from a convex surface), and the absence of a small-celled element. The lateral geniculate body of *Tarsius*, while exhibiting certain resemblances to that of the Anthropeidea, shows individual peculiarities in the absence of a distinct magnocellular element (which seems to be present in all other Primates), and in the manner in which the whole nucleus has been rotated so that the optic radiations emerge from a rostrally directed "hilum." Taking these points into consideration, and bearing in mind especially the great variability in complexity of the dorsal nucleus of the lateral geniculate body in the higher Primates, and even among the Simiidae, it is difficult to believe that the common progenitor of the suborders of the Primates could have possessed a lateral geniculate body much more differentiated than in *Tupaia* (in which the laminae are no more convoluted than in *Microcebus*, and there is no definite magnocellular element). We must infer therefore that, as in the case of the visual cortex, there has been some degree of parallelism in the evolution of these suborders.

The optic nerves and tracts of the hypothetical early Primate were no doubt large. This indeed is probably a primitive mammalian feature, as may be inferred from a consideration of their development in typical reptilian brains. It is probable, further, that a considerable proportion of the optic fibres remained uncrossed in the optic chiasma, seeing that this is the case in *Microcebus* and also (according to Zichen) in *Tarsius*. In other words, there is reason to believe that the neural basis of stereoscopic vision had been evolved to some degree before the divergence of the suborders of the Primates. On the other hand, there is evidence that no macula had developed in the retina. In the Lemuroidea, and in at least one representative of the Anthropeidea (*Nyctipithecus*), the macula is absent. In *Tarsius* Woollard has described a specialized central area in the retina, which he has termed a primordium maculae, but it is to be noted that in its histological structure it bears no relation to a true macula such as is found in most of the Anthropeidea.

Of the other elements of the thalamus, the large-celled nucleus of the optic tract was much better developed than in the majority of the existing Primates, as evidenced by its condition in *Microcebus* and *Tarsius*. While the anterior nuclei, dorso-medial nucleus, ventral nucleus, and the centre median nucleus could hardly have advanced beyond the stage represented in the brain of *Tupaia*.

The mid-brain of the ancestral Primate probably possessed a large anterior colliculus, associated with the large mesencephalic element of the optic tract. This structure remains of considerable size in *Microcebus* and *Tarsius*, though in neither does it reach the relatively huge proportions of the anterior colliculus in *Tupaia*. In this insectivore the tectum, with its large globular anterior colliculus and diminutive posterior colliculus, has a curiously reptilian appearance. The anterior colliculus in this form, however, is not directly comparable with the optic lobe of reptiles, since it is a solid structure.

Elliot Smith has noted his surprise at finding such a simple cerebellum as that of *Tarsius* among the Primates, and he compares it directly with that of primitive marsupials. The cerebellum of *Microcebus* shows only a slight advance on this simple form. We must infer therefore that the cerebellum of the ancestral Primate was equally primitive, with small lateral lobes connected by an attenuated pons, a simple and relatively poorly fissured vermis, and no paramedian lobe. Such a cerebellum is paralleled among the lowliest insectivores, and is surpassed by the cerebellum in *Tupaia*.

This discussion leads to the conclusion that the brain of the ancestral Primate form which gave rise to existing Primates must have been extremely primitive, and, indeed, could have been not much more elaborate than the brain of the modern Tupaiidæ. The evidence of cerebral anatomy therefore raises no difficulty in the way of conceiving a transition from a generalized type of insectivore to a form which may be regarded as a primitive and generalized Primate. Moreover, it seems certain that from such an undifferentiated form the three main groups of the Primates commenced to diverge in very early times, presumably early Paleocene or Cretaceous. It follows from this that there must have been a considerable degree of parallel evolution in these suborders. Such features as the central fissure, parallel fissure, etc., the differentiation of the lateral geniculate body, the complete differentiation of certain of the cortical areas, the elaboration of the cerebellum, with the formation of lobes such as the paramedian, have been evolved in different groups apparently independently. This parallelism, however, may readily be regarded as a manifestation of Osborn's postulate that descendants of a common ancestor tend to develop along similar lines. By adopting the corollary of this postulate it may be argued that the tendency among the various groups of the Primates to develop brains of such similar proportions, with similar disposition of cerebral sulci, similar arrangement of nuclear masses, etc., is a strong indication of their genetic affinities. No doubt this viewpoint leads to a strictly orthogenetic interpretation of evolutionary progress, but the rich and detailed researches into comparative anatomy during recent years lead more and more to such a conclusion.

LITERATURE CITED.

1. BRODMANN, K. Die Cytoarchitektonische Cortexgliederung der Halbaffen. Journ. für Psych. u. Neur., 1907-08.
2. BRODMANN, K. Vergleichende Lokalisations-Lehre der Grosshirnrinde. Leipzig, 1909.
3. BRUNNER, H., & SPIEGEL, E. A. Vergleich.-anatomische Studien am Hapaliden-gehirn. Folia Neurobiologica, Bd. 11, 1918.
4. CLARK, W. E. LE GROS. The Brain of *Tupaia minor*. Proc. Zool. Soc. London, December 1924, p. 1053.
5. CLARK, W. E. LE GROS. The Anatomy of the Pen-tailed Tree-shrew. Proc. Zool. Soc. London, December 1926, p. 1179.
6. CLARK, W. E. LE GROS. The Thalamus of *Tupaia minor*. Journ. of Anat. vol. lxxiii. 1929, p. 117.
7. CLARK, W. E. LE GROS. The Thalamus of *Tarsius*. Journ. of Anat. vol. lxxiv. 1930, p. 371.
8. ELLIOT SMITH, G. Catalogue of the Physiological Series of Comparative Anatomy in the Museum of the Royal College of Surgeons of England. Vol. ii. 1902.
9. ELLIOT SMITH, G. On the Morphology of the Brain in the Mammalia. Trans. Linn. Soc. (Zool.) vol. viii. 1903, p. 319.
10. ELLIOT SMITH, G. Discussion on *Tarsius*. Proc. Zool. Soc. London, 1919.
11. KOENIGST, S. Zur vergleichenden Morphologie des lateralen Kniehöckers der Säugethiere. Arbeit. aus dem Neur. Inst. an der Wien Univ. Bd. 30, 1927.

12. MAYER, O. Mikrometrische Untersuchungen über die Zelldichtigkeit der Grosshirnrinde bei der Affen. Journ. f. Psych. u. Neur. Bd. 19, Heft 6, 1912, p. 233.
13. PINES, J. L. Zur Architektonik des Thalamus Opticus beim Halbaffen. Journ. f. Psych. u. Neur. Bd. 33, 1927, p. 31.
14. RIOCH, D. M. Studies on the Diencephalon of the Carnivora. Journ. Comp. Neur. vol. xlix. 1929, p. 1.
15. RIOCH, D. M. The Centre Median Nucleus of Luys. Journ. of Anat. vol. lxxv. Part 3, 1931, p. 324.
16. ROSE, M. Histologische Lokalisation der Grosshirnrinde bei kleinen Säugethieren. Journ. f. Psych. u. Neur. Bd. 19, 1912, p. 119.
17. TILNEY, F. The Brain-stem of *Tarsius*. Journ. Comp. Neur. vol. xliii. 1927, p. 371.
18. WOOLLARD, H. H. The Anatomy of *Tarsius spectrum*. Proc. Zool. Soc. London, 1925, p. 1071.
19. WOOLLARD, H. H. The Cortical Lamination of *Tarsius*. Journ. of Anat. vol. lx. 1925, p. 86.
20. WOOLLARD, H. H. Epioritic and Dysoritic Systems in a Primitive Primate. Journ. of Anat. vol. lxxii. 1928, p. 276.
21. WOOLLARD, H. H., & BEATTIE, J. The Comparative Anatomy of the Lateral Geniculate Body. Journ. of Anat. vol. lxi. 1927, p. 414.
22. VOGT, C. La Myéloarchitecture du Thalamus du Cercopithèque. Journ. f. Psych. u. Neur. Bd. 12, 1909, p. 285.
23. ZIEHEN, T. Ueber den Bau des Gehirns bei den Halbaffen und bei *Galenopithecus*. Anat. Anz. Bd. 22, 1903, p. 506.

EXPLANATION OF THE PLATES.

Microphotographs (untouched) of transverse sections through the brain of *Microcebus*.
Stained with Borell's methylene blue. $\times 15$.

PLATE I.

- Fig. 1. Section 158, at level of rostral extremity of corpus callosum.
2. Section 217, at level of caudal extremity of olfactory bulb.

PLATE II.

Section 295, at level of tip of temporal lobe.

PLATE III.

Section 336, at level of anterior nuclei of thalamus and anterior border of optic chiasma.

PLATE IV.

Section 410, at level of tuber cinereum.

PLATE V.

Section 461, at level of anterior margin of lateral geniculate body.

PLATE VI.

Section 490, through middle of lateral geniculate body and anterior margin of anterior colliculus.

PLATE VII.

Section 546, through middle of medial geniculate body and red nucleus.

PLATE VIII.

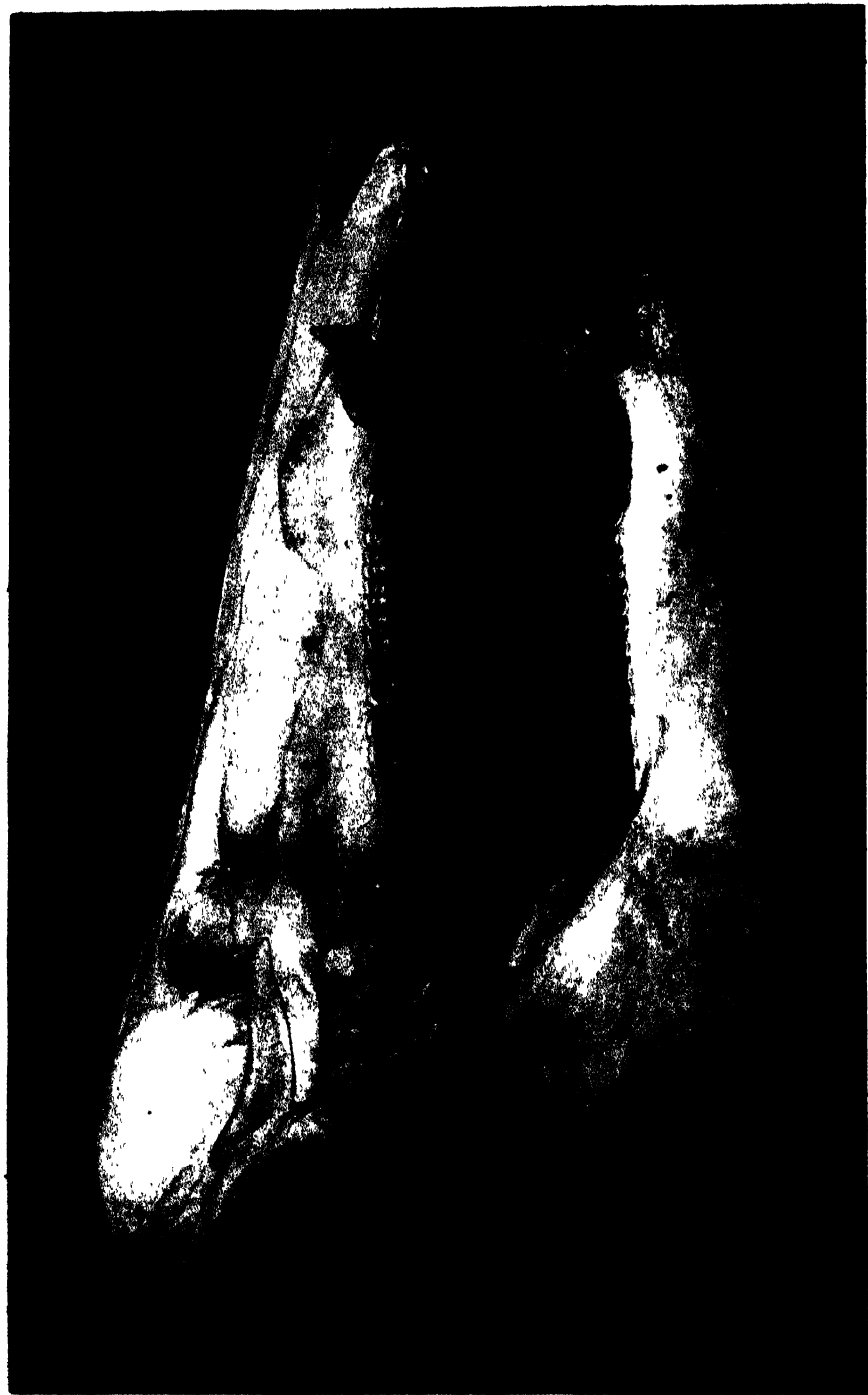
Section 601, through retrocalcarine sulcus and posterior colliculus.

Abbreviations in Plates.

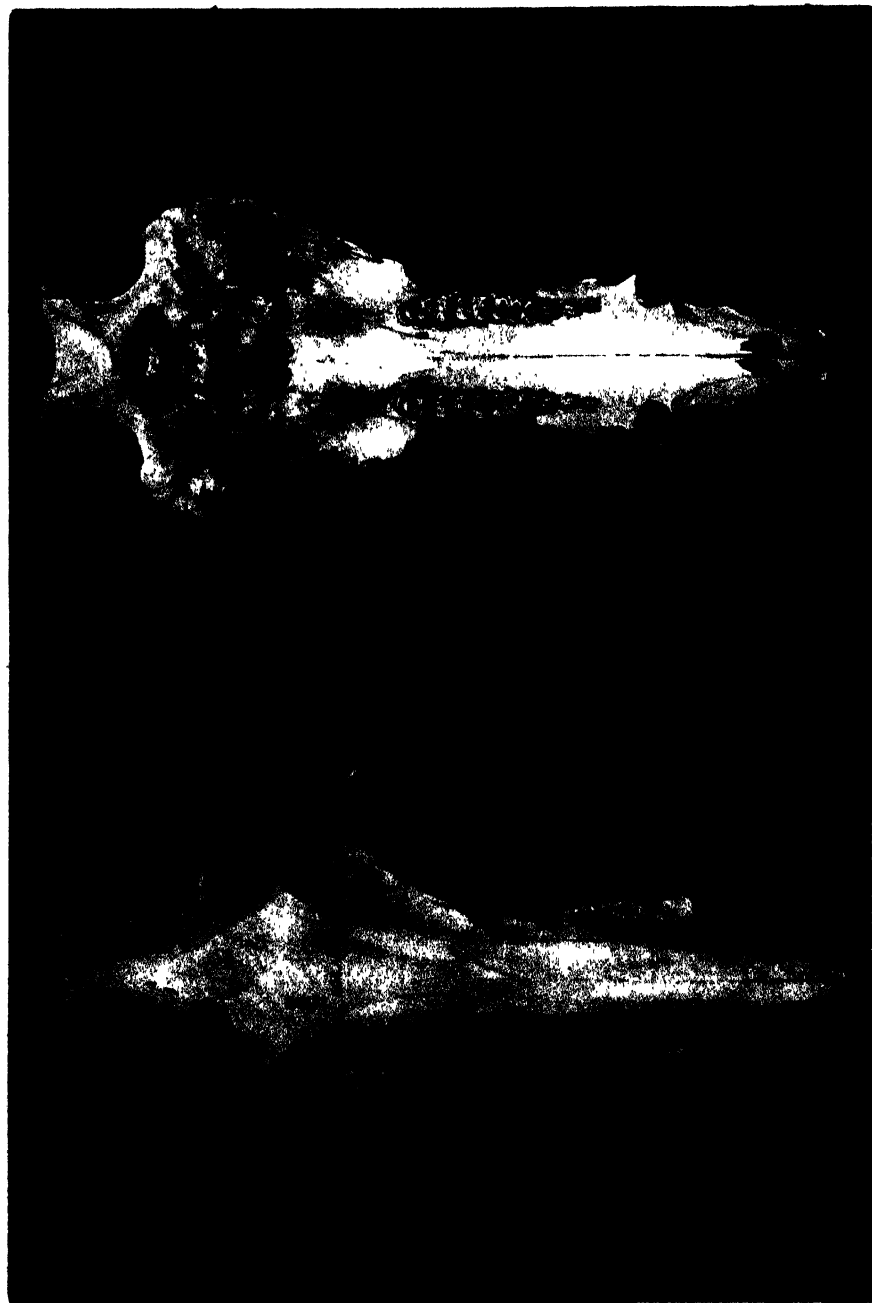
| | |
|---|---|
| <i>A.C.</i> Anterior Colliculus. | <i>M.</i> Corpus Mammillare. |
| <i>Ad.</i> Nucleus Anterior Dorsalis. | <i>M.th.</i> Tractus Mammillo-thalamicus. |
| <i>Am.</i> Nucleus Anterior Medialis. | <i>N.l.t.</i> Nucleus lateralis tegmenti. |
| <i>Am.B.</i> Nucleus Amygdaloideus Basalis. | <i>N.P.C.</i> Nucleus of Posterior Commissure. |
| <i>Am.C.</i> Nucleus Amygdaloideus Centralis. | <i>N.R.</i> Nucleus Ruber. |
| <i>Am.Co.</i> Nucleus Amygdaloideus Corticalis. | <i>L.</i> Nucleus Lateralis. |
| <i>Am.L.</i> Nucleus Amygdaloideus Lateralis. | <i>N.O.</i> Nervus Opticus. |
| <i>Am.M.</i> Nucleus Amygdaloideus Medialis. | <i>Ot.</i> Large-celled Nucleus of Optic Tract. |
| <i>Aq.</i> Aqueduct of Sylvius. | <i>O.R.</i> Optic Radiations. |
| <i>Av.</i> Nucleus Anterior Ventralis. | <i>P.</i> Pulvinar. |
| <i>Bt.</i> Inferior Brachium. | <i>Par.</i> Parolfactory Area. |
| <i>B.O.</i> Bulbus Olfactorius. | <i>P.C.</i> Posterior Colliculus. |
| <i>C.C.</i> Corpus Callosum. | <i>P.Cm.</i> Posterior Commissure. |
| <i>Cd.</i> Nucleus Caudatus. | <i>Pc.</i> Nucleus Paracentralis. |
| <i>Cl.</i> Claustrum. | <i>Pit.</i> Pituitary Gland. |
| <i>C.M.</i> Centre Median Nucleus. | <i>Pt.</i> Nucleus Pretectalis. |
| <i>Dm.</i> Nucleus Dorso-medialis. | <i>P.t.n.</i> Nucleus Parataenialis. |
| <i>Ent.</i> Nucleus Entopeduncularis. | <i>Pu.</i> Putamen. |
| <i>Ep.</i> Epiphysis. | <i>R.</i> Nucleus Reticularis. |
| <i>F.</i> Fornix. | <i>Rh.</i> Rhinencephalon. |
| <i>F.C.</i> Fornix Commissure. | <i>S.</i> Subiculum. |
| <i>Fi.</i> Fimbria. | <i>Sg.</i> Nucleus Suprageniculatus. |
| <i>F.R.</i> Fasciculus Retroflexus. | <i>S.M.</i> Stria Medullaris. |
| <i>G.D.</i> Gyrus Dentatus. | <i>S.n.</i> Substantia Nigra. |
| <i>G.I.</i> Ganglion Interpedunculare. | <i>S.S.</i> Suprasylvian Sulcus. |
| <i>G.L.d.</i> Lateral Geniculate Body, nucleus dorsalis. | <i>Sth.</i> Nucleus Subthalamicus |
| <i>G.L.v.</i> Lateral Geniculate Body, nucleus ventralis. | <i>Tb.O.</i> Tuberculum Olfactorium. |
| <i>G.M.c.</i> Medial Geniculate Body, pars centralis. | <i>T.O.</i> Tractus Opticus. |
| <i>G.M.l.</i> Medial Geniculate Body, pars lateralis. | <i>T.O.l.</i> Tractus Olfactorius Lateralis |
| <i>G.M.v.</i> Medial Geniculate Body, pars ventralis. | <i>V.</i> Nucleus Ventralis. |
| <i>H.</i> Hippocampus. | <i>Z.I.</i> Zona Incerta. |
| <i>Hb.L.</i> Nucleus Habenularis Lateralis. | 3. Oculomotor nerve. |
| <i>Hb.m.</i> Nucleus Habenularis Medialis. | 3n. Nucleus of Oculomotor Nerve. |
| <i>H.t.</i> Hippocampal Tubercle. | 5. Trigeminal Nerve. |
| | 5g. Ganglion of Trigeminal Nerve |

Cortical Areas. (Brodmann's numbers.)

| | |
|-----------------------------|----------------------------------|
| 1-3. Area Postcentralis. | 20. Area Temporalis Inferior. |
| 4. " Precentralis. | 21. " Temporalis Medius. |
| 5. " Preparietalis. | 22. " Temporalis Superior. |
| 6. " Frontalis Agranularis. | 23. " Limbica Posterior. |
| 7. " Parietalis. | 24. " Limbica Anterior. |
| 13-16. " Insularis. | 25. " Progenualis. |
| 17. " Striata. | 27. " Presubicularis. |
| 18. Occipitalis | 30. " Retro-limbica Agranularis. |



SKULL 0 *SUS GARGANTUA* - CAMBRIDGE MUSEUM



John Day's Sons & Deardorff, Ltd., London.

2.

1.

SKULL OF *SUS GARGANTUA* - CAMBRIDGE MUSEUM.

24. Note on a Skull of *Sus gargantua* Miller in the Cambridge Museum.

By B. W. TUCKER, M.A., F.Z.S., University Demonstrator in Zoology and Comparative Anatomy, Oxford.

[Received December 30, 1930 : Read March 17, 1931.]

(Plates I. & II. * ; Text-figures 1 & 2.)

Sus gargantua was described in 1906 by Gerrit S. Miller, Jun., from a single skull of a young adult male animal collected in South-eastern Borneo in 1882 by Grabowsky, and now in the Agricultural High School at Berlin.

The skull differs from that of the ordinary Bornean *Sus barbatus* in being considerably larger, with the occipital region conspicuously low and overhanging and the lower surface of the occipital condyle scarcely above the level of the alveolar line, instead of being elevated more or less considerably above it. This distinction is well brought out in a diagram, a copy of which is reproduced here (text-fig. 1).

Some time ago, in the course of a study of cranial variations in *Sus*, on which I have been engaged intermittently for several years, my attention was attracted by a male skull amongst the *barbatus* material in the University Museum of Zoology at Cambridge which was clearly differentiated from the others by its large size and peculiar characters. A closer examination established beyond question that this was a skull of the same form as that described by Miller. It has exactly the same low backwardly projecting occiput and the same lowered position of the condyles relatively to the alveolar border, as will be sufficiently clear from text-fig. 2, taken from an outline drawing made with Hermann's diopetrograph apparatus.

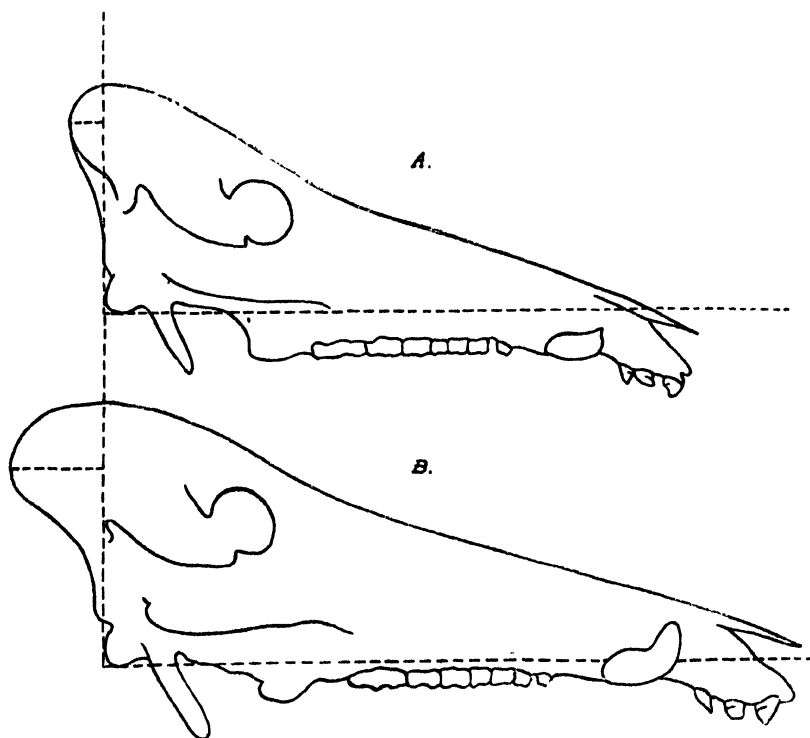
The Cambridge specimen †, which I am now able to describe and figure through the kindness of Mr. C. Forster Cooper, although decidedly larger than any *barbatus* skull I have examined, is not quite as large as the type of *S. gargantua*, the upper and basal lengths being 527 and 434 mm. respectively, as compared with 570 and 455 mm. in the Berlin skull. It is, however, apparently a little older, the teeth being rather more worn and the basioccipital suture, which is open in the type, closed up.

Miller brings out two of the most noteworthy differences from *barbatus* by means of percentage measurements. The relative height of the skull of *Sus gargantua* when resting on the mandibles is notably less than in the smaller animal, this being principally due, as he points out, "to the less relative elevation of the condyle above the under surface of the lower jaw." The ratio of the height of the skull resting on the mandibles to the basal length is given by Miller as 53.8 per cent., as against about 60 per cent. in *barbatus*. In the present specimen it is 53.7 per cent., the agreement being thus extremely close. The other ratio quoted by Miller is that of the upper or profile length to the basal

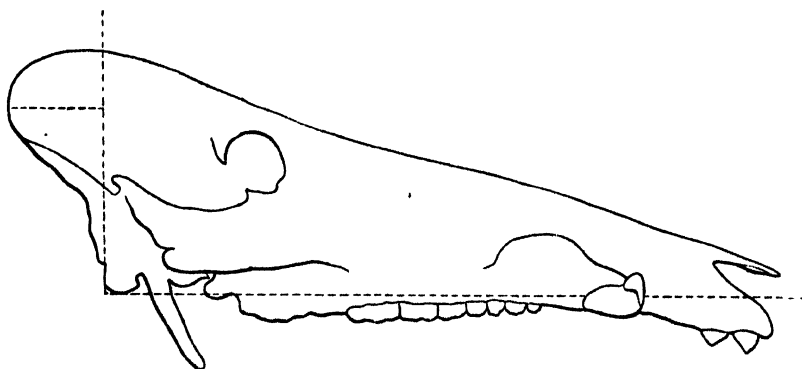
* For explanation of the Plates, see p. 492.

† The skull is No. H. 12632 (694 AF) in the Cambridge collection.

Text-figure 1.

Diagrammatic comparison of skulls of *Sus barbatus* (A) and *Sus gargantua* (B) (after Miller).

Text-figure 2.

Outline of the skull of *Sus gargantua* at Cambridge for comparison with text-fig. 1 (B).

length, which is said to be 123.1 in *gargantua* * and about 117 in *barbatus*. In the Cambridge skull it is 121.4. The difference is most probably due to the occiput in the latter being more deeply concave than in the other specimen, so that the length in the middle line is relatively rather less, since, viewed from the side, the backward extension of the occiput appears quite as great.

Comparison of the photographs of the type with the present specimen reveals a further apparent difference from normal *barbatus* which is seemingly worthy of note. The upper molars in both specimens are rather further forward relative to the posterior palatine foramina than is usual in normal *barbatus*. The hind end of the posterior palatine foramen is on a level with the middle of M. 3, or, indeed, rather behind the middle. In *barbatus* there is some individual variation, but usually it is approximately on a level with the middle of the first transverse row of cusps. Occasionally it is rather further back, but with a solitary exception is never, in any of the considerable number of *barbatus* skulls at Oxford, Cambridge, and the British Museum which I have examined, so far back as the middle of the tooth. This single exception is skull no. 55.12.26.153 in the British Museum series, which in other respects is ordinary typical *barbatus*, but has the hind end of the foramen approximately on a level with the hind end of M. 3. This condition must, however, be regarded as altogether exceptional in *Sus barbatus*, and the occurrence of a comparable forward shifting of the teeth relatively to the foramina in both of the two known specimens of the other form would appear to be significant.

Apart from the above-noted characters I can find no other significant differences between the two forms, though it remains to be seen whether, when a closer comparative study of percentage measurements of different parts of the skull is undertaken in connection with the general investigation of cranial variations above-mentioned, any less noticeable differences of proportion will be revealed. In the accompanying table Miller's measurements

* It is, perhaps, not superfluous to observe that there has been a curious lack of consistency in the quotations of measurements of this skull in different papers. It was first described by Nehring (1885 & 1889), who supposed that the animal to which it belonged was identical with Muller's *Sus barbatus*, while, as is well known, he described the true *barbatus* of Muller under the name of *Sus longirostris*. He gives the profile length of the present skull as 554 mm. and the basal length as 450 mm. Miller, on the other hand, as stated above, gives the upper length (presumably the same thing as Nehring's profile length) as 570 mm. and the basal length as 455 mm. The above-mentioned ratios, however, are taken by him from a paper by Forsyth Major (1897), who calculated them from Nehring's measurements. If Miller's own measurements are used the ratios are slightly different, namely, approximately 53.2 and 125.3. Not having examined the specimen I have adhered in the above account to Forsyth Major's figures, which Miller himself follows, and which agree better with those for the Cambridge skull.

A further element of confusion has been introduced by Jentink. In his important '*Sus studies in the Leyden Museum*' (1905), having referred to the Berlin skull (p. 158) and correctly quoted Nehring's measurements of the profile length (554 mm.), he says (p. 160): "There has been figured by Nehring ('*Die Rassen des Schweines*,' p. 20, fig. 4) a Pig-skull from the Zool. Sammlung d. Landwirtschaftl. Hochschule in Berlin as 'Schädel eines männlichen Bartschweines aus Borneo. $\frac{1}{2}$ nat. Gr.' It measures 562 mm. It therefore is a good deal larger than the largest known *barbatus* skull," etc. But this is the same skull dealt with by him two pages before and now under discussion, namely, no. 4066 in the collection of the Landwirtschaftliche Hochschule, and the figure is the same as appears in Nehring's '*Sus celebensis und Verwandte*' (1889, p. 21). It might appear, therefore, from Jentink's remarks that Nehring himself gave different measurements for the same skull in different papers. But a reference to '*Die Rassen des Schweines*' (1891, p. 20) shows that this is not the case. The profile length is there given as 554 mm. as in the other papers, and there is nothing about 562 mm. Apparently Jentink simply calculated this length on the basis of the legend " $\frac{1}{2}$ nat. Gr." under the figure, by simply multiplying the length of the figure by five, overlooking the fact that the skull illustrated is the one specifically referred to in the text. This proceeding would give a length of approximately (but not exactly) 562 mm., which figure may indeed be roughly correct for the maximum length reckoned to the lateral angles of the occiput instead of to the middle point.

of the Berlin skull are given, with the corresponding measurements of the Cambridge specimen for comparison.

TABLE OF MEASUREMENTS OF SKULLS OF *SUS GARGANTUA*.

| | Berlin specimen (Miller). | Cambridge specimen. |
|--------------------------------|------------------------------|---------------------|
| Upper length | 570 | 527 |
| Basal length | 455 | 434 |
| Palatal length | 367 | 349 |
| Width of palate at PM. 1 | 50 | 48 |
| Zygomatic breadth | 185 | 181 |
| Least interorbital breadth | 83 | 78 |
| Nasal breadth | 43 | 42.5 |
| Length of nasals | 278 | 274 |
| Occipital depth to basion | 167 | 154 |
| Length of mandible | 395 | 379 |
| Maxillary tooth-row (alveoli) | 137 | 131 |
| Third upper molar | 37 × 23 | 38 × 22 |
| Mandibular tooth-row (alveoli) | 140 | 131 |
| Second lower molar | 22 × 17 | 22 × 16 |
| Third lower molar | 17 × 21 | 42 × 19.5 |

In Lydekker's 'Catalogue of the Ungulate Mammals in the British Museum' (vol. iv. 1915, p. 341) Miller's pig is described as *Sus barbatus gargantua*, and three skulls catalogued under *Sus barbatus barbatus* are mentioned as possibly belonging to this form. The words are "No specimen in collection unless nos. 10.4.5.132-3 and 10.4.5.158, entered under heading of the preceding race, should belong to the present one." I have examined these three skulls, which come from the Barito Valley, South Central Borneo, and are all immature, and find no ground whatever for supposing that they belong to *S. gargantua*. Presumably, therefore, the above possibility was considered by Lydekker not on the ground of any positive character, but simply because they came from a more southerly part of Borneo than the others in the British Museum collection, and were of an age at which the distinguishing characters of *gargantua* might not be readily recognizable. Nos. 10.4.5.132 and 133 are immature males with M. 3 not yet cut. No doubt the peculiar features of the larger form would be expected to be less marked in young animals than in older ones; but even so, I find nothing in these skulls which would favour the supposition that they are anything but normal *barbatus*. The third, 10.4.5.158, is a male with high occiput, which it is quite obvious at a glance has no resemblance at all to *Sus gargantua*.

The real status of the so-called *Sus gargantua* is by no means clear. The question is not so much whether it should be treated as a species or as a subspecies of *S. barbatus*, which is of secondary importance, as whether it is really a valid form at all. If it is it seems fairly clear that it should rank as a species, since apparently it and *barbatus* occur together; but the possibility that it is no more than a well-marked individual variant of the latter cannot at present be entirely excluded.

Jentink, independently of Miller, came to the conclusion (1905, p. 150) that the skull must be that of "an unknown very large Borneo-pig," and Kloss (1921) is also inclined to believe that it is genuinely distinct. He says "If *Sus gargantua* is not an example of *barbatus* of abnormal shape and size (and there is no reason to believe that it is) it must be a distinct species, since

gargantua and *barbatus* occur side by side." He also finds indirect support for this view in the interesting reports of the existence of an analogous gigantic animal in Sumatra, which would occupy the same position relatively to the ordinary Sumatran *Sus oi* as *gargantua* apparently does to *barbatus* in Borneo *. On the morphological side also the characters appear to be well defined, yet there are some puzzling features in the case.

The type-specimen came from South-Eastern Borneo, and for years it has remained the only one known. This in itself seems curious if the skull really represents a distinct species or race. But the Cambridge example, which is undoubtedly the same thing as Miller's *gargantua*, does not come from the same district at all. It was shot by the late Dr. Charles Hose in the Baram district of Sarawak, in the very same area where the same naturalist shot dozens of typical *Sus barbatus*, some of whose skulls are in the Cambridge Museum along with the one under consideration. The wide separation of the places of origin of the two specimens practically rules out any possibility, which might otherwise have been entertained, that *gargantua* might be a peculiar local form of *barbatus* occasionally straying into the area occupied by the typical form. Whether in any case the differentiation of more than one geographical race in an area like Borneo can be considered likely may be open to question. On such matters it is not easy for the zoologist at home, having no first-hand knowledge of the country, to form an opinion of much value.

But it is natural to ask whether, if this animal had showed any appreciable difference from ordinary *barbatus*, as it might fairly be expected to do if *gargantua* were really a distinct species, some note to this effect would not have been kept by the able naturalist who collected it. This consideration seems definitely unfavourable to the species theory, but the matter can only finally be settled by investigation on the spot. The present writer would venture, however, to suggest quite tentatively that perhaps *Sus gargantua* is not a valid species or race at all, but simply an occasional aberration of *Sus barbatus*—possibly a peculiar large mutant form, in which large size is correlated with the special occipital characteristics above described. It is even perhaps conceivable that any individual of *barbatus* attaining an abnormally large size may tend to develop this depressed type of occiput.

REFERENCES.

- FORSYTH MAJOR, C. I. (1897) On *Sus verrucosus* Mull. & Schleg., and Allies, from the Eastern Archipelago. Ann. & Mag. Nat. Hist. ser. 6, vol. xix, pp. 521-42.
- JENTINK, F. A. (1905.) *Sus*-studies in the Leyden Museum. Notes from the Leyden Museum, vol. xxvi. pp. 155-95.
- KLOSS, C. B. (1921.) Malaysian Bearded Pigs. Journ. Straits Branch R. Asiatic Soc. lxxxiii. p. 147.
- LYDEKKER, R. (1915.) Catalogue of the Ungulate Mammals in the British Museum, vol. iv. p. 341. British Museum, London.
- NEHRING, A. (1885.) Ueber eine neue Art von Wildschweinen (*Sus longirostris* Nehring) aus Sudost-Borneo. Zool. Anz., Bd. viii. pp. 347-53.

* "In this connection it is interesting to note that the Malays inhabiting the central parts of Eastern Sumatra and some of the islands closely adjacent report the existence there of another pig much larger than *Sus oi* and regarded by them as quite distinct from it the 'Babi branti'—in habits nomadic and consorting in droves. There is no reason to doubt the statements, which indicate a Sumatran analogue to the Bornean *Sus gargantua*, thus paralleling the case of *oi* and *barbatus*."

- NEHRING, A. (1889.) Ueber *Sus celebensis* und Verwandte. Abhandl. u. Ber. Kgl. Zool. anthrop.-ethnogr. Mus. Dresden, 1888-9, no. 2, pp. 1-34.
- NEHRING, A. (1891.) Die Rassen des Schweines. Rohde's Schweine-zucht, pp. 1-38. Berlin.
- MILLER, G. S., Jun. (1906.) Notes on Malayan Pigs. Proc. U.S. Nat. Mus. vol. xxx. pp. 737-58.

EXPLANATION OF THE PLATES.

PLATE I.

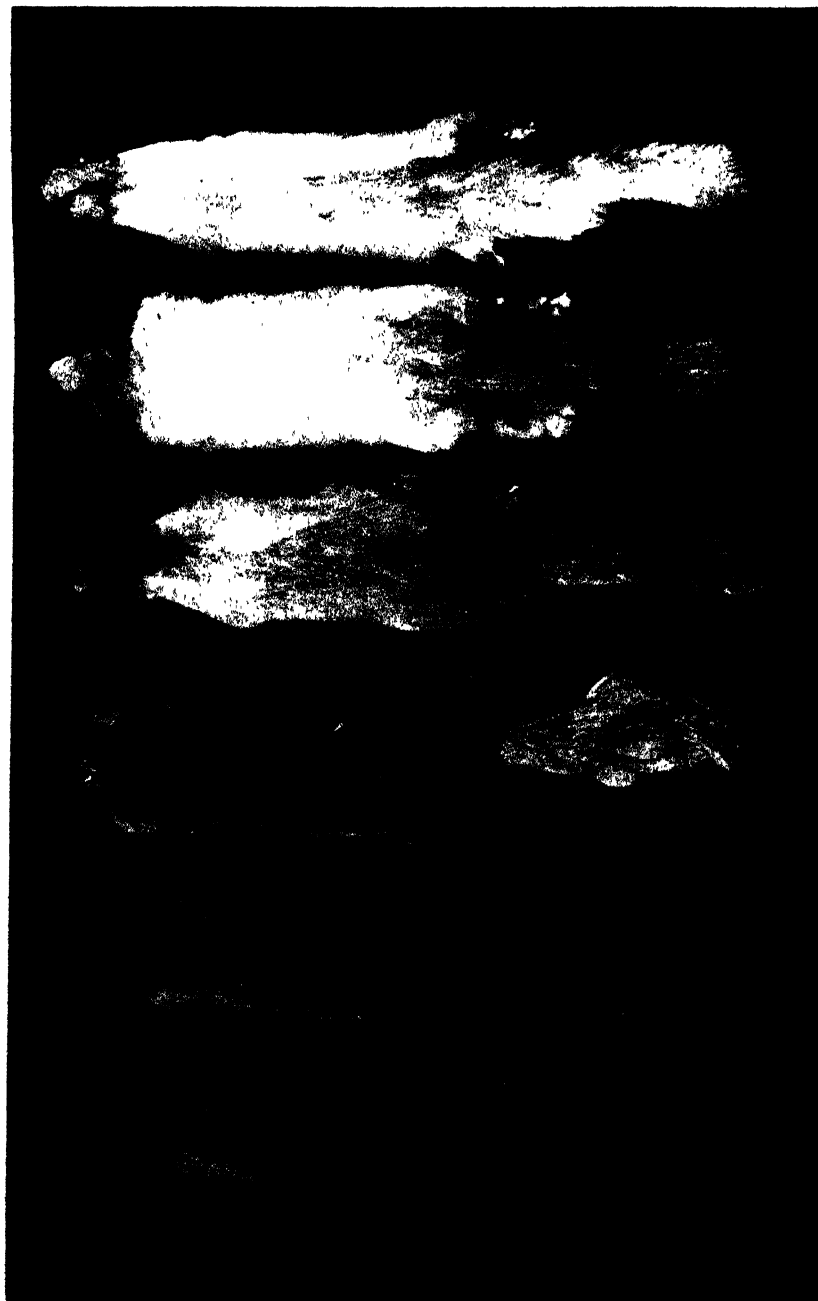
Skull of *Sus gargantua*, Cambridge Museum; lateral view of skull and lower jaw.

PLATE II.

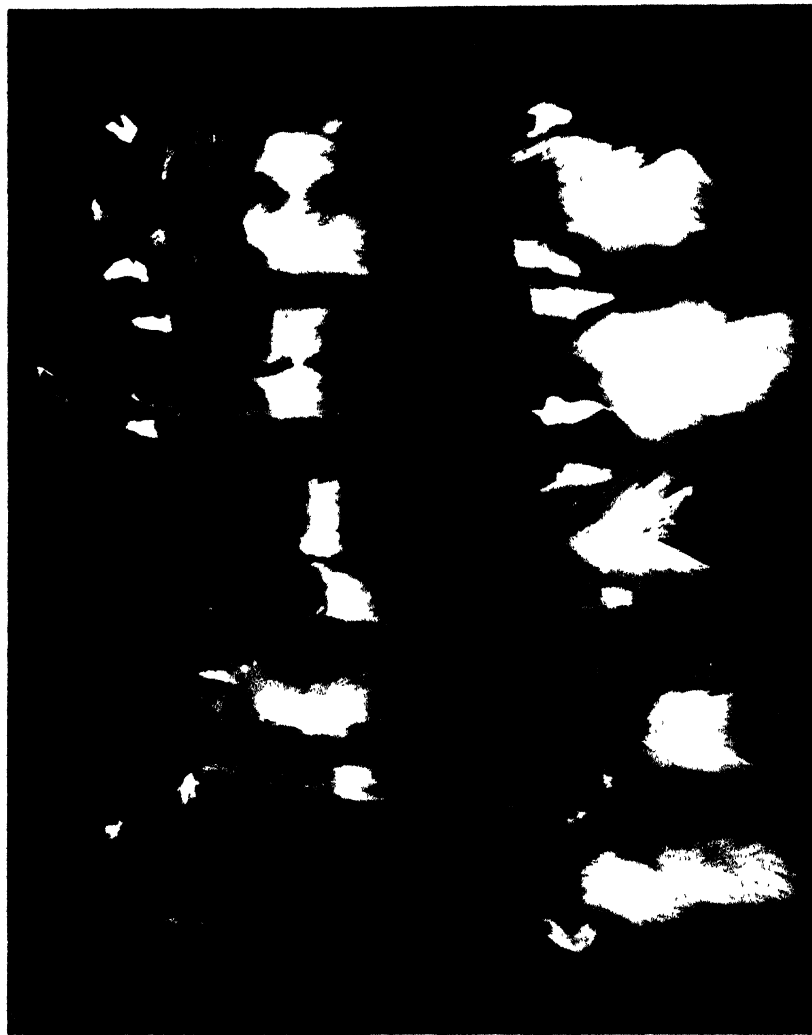
Skull of *Sus gargantua*, Cambridge Museum.

Fig. 1. Dorsal view.

2. Palatal view.



POLYCHROMATISM AND ALBINISM OF SIBERIAN SQUIRRELS.



Сибирские белки. 1. 1931.

POLYCHROMATISM AND ALBINISM OF SIBERIAN SQUIRRELS.

25. On the Polychromatism and Albinism of the Siberian Squirrels.

By M. K. SEREBRENNIKOV (Leningrad) *.

[Received October 21, 1930 : Read February 17, 1931.]

(Plates I.-III.)

ECOLOGICAL POLYCHROMATISM.

The classification of squirrels in reference to the species *Sciurus vulgaris* L. has presented great difficulties in consequence of the variability of colour of these animals. Such an authority as the late Mr. Oldfield Thomas said :—" In conclusion, I may remark that the above wonderful changes in the British Squirrel are, both in effect and complexity, quite unparalleled throughout the mammals of the world, so far as I am aware. Had any such peculiarity occurred elsewhere it must have been noticed before, but being at our very doors no one has till now commenced any serious investigation ; and the subject has been dismissed with a passing remark on the 'variability' of our Common Squirrel."

At the request of the Director of the Zoological Museum of the Russian Academy of Sciences, I have studied the classification of Russian squirrels, which are rather fully represented in the collections of the Museum. This material has given me the possibility of finding some valuable phenomena of the colour variability of Russian squirrels.

The most interesting form of such variability is the ecological polychromatism. Most fully, and in great variety, it is represented by the Middle-Siberian squirrels, and consists in the following three coloured morphs which may sometimes occur together, but are mostly, to a certain degree, ecologically isolated. In the coniferous forests in which the cedar (*Pinus cembra*) is prevailing, the black-tailed morph, "*Morpha nigricauda*" (Pl. I. fig. 1) occurs, with a black tail and ear-tufts, with a dark grey winter pelage or a blackish-brown summer pelage. In forests with fir (*Abies sibirica*) and *Picea obovata*) and larch (*Larix sibirica*) instead of cedar, we find the brown-tailed morph, "*Morpha brunneicauda*" (Pl. I. fig. 2), with brown tail and ear-tufts, with a grey winter pelage or a dark brown summer pelage. In pine-forests (with *Pinus sylvestris*) we find pre-eminently the red-tailed morph "*Morpha ruficauda*" (Pl. I. fig. 3), with red tail and ear-tufts, with a light grey winter pelage and a red summer pelage.

It must be pointed out that we can speak only relatively of the predomination of one or any other type of these three morphs in the Siberian forests. It is evident that the colour of squirrels does not only depend on the forest conditions, but that moisture, elevation of land, possibly kind of food, and other factors may interfere. Information to that effect may be found in existing literature. Moreover, the different forest conditions influence the colour, especially in parts where these conditions are most constant, where homogeneous forests occupy great areas, where, consequently, there is no possibility for the squirrels of frequent changes of station ; that has to be taken into consideration because of the extreme mobility of the squirrels and their inclination to great or small migrations.

* Communicated by MARTIN A. C. HINTON, F.Z.S.

In 1925 I myself happened to be in the Saján Mountains at the watershed between Kazir and Kizir Rivers, in regions lying close to those from which a great series of squirrels (86 specimens), collected by the Saján Sable Expedition of the Department of Agriculture during the summer, autumn, and winter of 1915, was brought to the Zoological Museum. Confronting the abundance of colour variation that is to be observed in that series with the forest conditions and the relief, and also taking into consideration the biological notes about squirrels that D. K. Solovjev gives us in his 'Accounts of the Saján Sable Expedition,' it is possible to establish a correlation between the colour of the squirrels and these exterior conditions of the mountainous forest and subforest zones of the Sajáns.

A considerable majority of dark-coloured specimens prevails in all that variety of differently-coloured squirrels. Thus, out of 86 specimens of that collection, 21 (or 24 per cent.) are black-tailed, 59 (or 69 per cent.) are brown-tailed, and only 6 or 7 per cent. are red-tailed.

The prevalent types of forests in the Saján Mountains, according to Belousov, in 'Accounts of the Saján Expedition,' are : the cedar-fir type on the old river sandbanks and fir-cedar type on mountain slopes, and then two temporal types with predomination of the same trees and with admixture of larch and birch. The pine as a component of these types is not mentioned at all. Indeed, I had the opportunity of ascertaining myself that the pine in the basin of Kizir and Kazir Rivers forms the minority, and is lost in the mass of the above-enumerated representatives of the flora.

I have to remind the reader that the red-tailed morph in the Saján Collection is represented only by 7 per cent.

Some other similar analyses and comparisons could be given. All of them confirm the opinions of the old author-travellers through Siberia (Schrenk, Radde, Middendorff), and also the opinions of Russian hunting-societies ; and now I myself am quite sure that there exist three forms :—"Belka-kedrovka," the black-tailed morph ; "belka-clovka," the brown-tailed ; and "belka-sosnovka," the red-tailed morph.

Summing up all that has been said of the ecological polychromatism of the Middle-Siberian Squirrels we may say : the darker the forest (*i. e.*, the more cedar and fir are prevailing), the damper is the microclimate, the greater the elevation of land, the darker are the squirrels ; and, *vice versa*, in dry, light pine-forests, on flat areas, lighter squirrels are to be found.

ALBINISM.

Material : 55 specimens of squirrels in the collection of the Zoological Museum of the Academy of Sciences.

Albinism occurs very often among the East Siberian Squirrels, especially among the squirrels of the forests of the Jakutsk and Tunguse regions. I divide that phenomenon into two categories :—(i.) *General albinism*, when the depigmentation extends proportionally over the whole pelage ; and (ii.) *partial albinism* (piedness or spottedness), when only some parts of the body are quite depigmented, and the rest of the pelage is not touched by albinism. Those two categories do not mix : there are no intermediate forms between them, and their nature is apparently quite different.

Speaking of the phenomenon of general albinism, we see that in different morphs it results differently. With the black-tailed morph, at the first stage of albinism, the ear-tufts and the tail, *i. e.*, the parts of pelage that are most intensively coloured, undergo the depigmentation first of all (Pl. II.). Then bleaching extends on the rest of the pelage. In the last stages of albinism the

black pigment remains only on the ear-tufts and on the tail, and in a very small quantity.

The red-tailed morph presents quite a different picture. Here the red pigment on the ear-tufts and the tail is most constant; it is preserved, to a certain degree, till complete whitening of the pelage takes place, and it is also possible that the red-tailed morph does not give complete albinos at all.

We also observe the same phenomenon among the brown-tailed morph. In the case of general whitening of pelage the brown pigment remains intact on ear-tufts and tail.

Thus the phenomena of general albinism among squirrels confirm the opinion that there exist three independent morphs, described above.

Partial albinism occurs among the black-tailed morph most often. It appears in the form of the cross-stripes of white fur that gird the body and limbs of the animal more or less symmetrically (Pl. III.). Parts that are especially subject to the whitening are the following:—First of all the tail (specimen no. 3637). The large collection of albinos does not provide us with a single specimen having signs of whitening on any other part of the body before the tail; on the contrary, there are several specimens with partly-coloured tails having preserved their normal colour on the rest of the pelage. The next parts of the body subject to whitening are the paws (specimen no. 3615). Further on the white stripe begins to gird the back, generally spreading here from the belly and the sides. Complete symmetry generally does not occur, but there is undoubtedly a certain regularity in the spreading of albinism over the body. In that stage the white fur appears also on the sides of the neck and on the sides of the muzzle.

Further on albinism results in the closing of the white girdle on the back (specimen no. 14111). The girdles of the back, the neck, and the tail, as well as those of the limbs, may be expressed in different degrees, but the above-mentioned sequence in the appearance of those girdles is constant.

COMPLETE ALBINISM.

It is impossible to state the origin of complete albinos, whether they originate from general or partial albinos, and therefore they must be examined apart.

There is a complete albino in its summer (August) pelage (no. 10194) in the Zoological Museum. The tail of that specimen has already a certain quantity of short-growing winter hair (long hair and under-fur). Thus this specimen is in the first phase of moulting. All the four categories (summer and winter) of hair are quite white, and apparently do not differ in structure from normal hair.

Another complete albino (no. 32, October 1907) has already only the winter pelage, though the hair has not reached its full length.

And lastly specimen no. 5026 has a complete winter pelage, also of quite normal structure.

General and partial albinism is to be observed on winter as well as on summer specimens, and on the adult as well as on the young ones.

26. Revision of the Genus *Hemipyrellia* Tns. (Diptera, Calliphoridae).

By D. AUBERTIN, M.Sc., F.L.S.*

[Received February 2, 1931 : Read April 28, 1931.]

(Text-figures 1-8.)

INTRODUCTION.

The species of the genus *Lucilia*, commonly known as Greenbottle Flies, are notorious in Africa and Australia owing to the damage caused by the attacks of the larvæ on sheep. While preparing a revision of this genus the necessity of revising the genus *Hemipyrellia* became apparent, since the species of the latter have only recently been recognized as forming a group distinct from *Lucilia*, and the systematics of the two genera are therefore intimately connected. Although one species of *Hemipyrellia* is very common in Africa and another in Australia, they have never been accused of injuring sheep, and the remaining species do not occur in sheep-farming countries.

The genus was erected by Townsend (1918) for the reception of an African species, *Lucilia fernandica* Macq., which he described under the name *H. curiei*, but no points of taxonomic value were brought out in the description, and Shannon (1924) therefore regarded *Hemipyrellia* as a synonym of *Lucilia*. Malloch (1926) realized that *L. fernandica* Macq. and one or two closely allied species, hitherto regarded as belonging to *Lucilia*, formed a very homogeneous group characterized by the upstanding hairs on the convexity above the metathoracic spiracle, and in 1929 he raised the group to the rank of a distinct genus. An examination of the genitalia of all the known species bears out this contention.

Hemipyrellia is restricted to the Old World, and at the present time eight species are known. The genotype, *Hemipyrellia fernandica* Macq., is common all over the Ethiopian Region, but is replaced in Madagascar, Mauritius, the Seychelles, and associated islands by a distinct species, *H. cyanea* F., which does not occur elsewhere. The species most nearly allied anatomically to *H. fernandica* Macq. is *H. pulchra* Wied., which is distributed very generally over the plains of India; from the examination of several large collections of Diptera it does not appear to be so common as *H. ligurriens* Wied., which also occurs in India and extends eastwards through Malay, S. China, Java, Celebes, the Philippine Islands, and Northern Australia. A further species, *H. tagaliana* Big., is found on the Philippine Islands, and probably has a restricted distribution among the neighbouring islands; the males are distinctive, but it is almost impossible to separate the females from those of *H. ligurriens* Wied. An endemic species, *H. jucunda* Kirby, occurring on Christmas Is. (Indian Ocean), is interesting on account of the great development of the male hypopygium. Two somewhat aberrant forms, *H. rhodocera* Bezzi and *H. fergusoni* Patton, have been described from the New Hebrides and Australia respectively;

* Communicated by Major E. E. AUSTEN, D.S.O., F.Z.S.

they appear, from an examination of the genitalia, to be closely allied, but differ rather markedly in this character from the remaining species in the genus. *H. fergusoni* Patton is also remarkable in that it belongs to the heterogeneous group of blue and orange Calliphorines which occur in Australia, while all the other species of *Hemipyrellia* are uniformly metallic green or blue. Except for *H. ligurriens* Wied., *H. tagaliana* Big., and *H. pulchra* Wied. the species do not overlap one another geographically, and this should be of great assistance in determining the identity of individual flies, especially the females, since the characters which separate the species from one another are mainly relative.

Three characters are of real value in distinguishing the species from one another. The male genitalia provide characters for the identification of each species in the penis, mesolobe, paralobes, and lateral lobes (text-fig. 1); these latter structures probably represent the ends of the tergite of the second hypopygial segment, and are a marked feature of this genus. The hairiness of the venter of the male varies from species to species both in distribution and thickness; the first visible sternite frequently has long, soft, curly hair, and the edges of the tergites are generally provided with bunches of stiff bristles. The third good taxonomic character is the width of the frons and parafrontals in the male. This width does not appear to be subject to great variation within the species, and in conjunction with the other characters affords a certain means of identification.

Characters of less importance, applicable to both males and females, are the shape and hairiness of the jowls, the distance to which the vibrissæ extend up the facialia, together with the relative density of the bristles and the colour of the antennæ. This last character should be used with caution; all the specimens of *H. pulchra* which I have seen have brilliant orange antennæ, but I have also seen undoubted specimens of *H. ligurriens* Wied. with orange antennæ, although in this species they are generally brown or almost black.

A further character of some value is the amount of dusting on the abdomen in both sexes.

Colour, except in *H. fergusoni* Patton, is a useless criterion, as specimens in each species may range from green to dark blue or almost purple; the green forms generally show dark bands on the posterior margins of the abdominal tergites, but in the blue forms the bands become merged in the general body coloration, and the character is therefore unreliable for purposes of identification.

The chaetotaxy in this genus is similar in all species and appears to show less tendency to variation within the species than in *Lucilia*.

As already noted the synonymy of the species of the genus is closely involved with that of the species of *Lucilia*, and has been complicated by the fact that no very clear conception of the Oriental species of this genus has so far been established. The synonymy of each species will be discussed in the systematic part of the paper.

I have to thank Dr. Zerny, of Vienna, for allowing me to examine Wiedemann's types and other material in his possession; Dr. van Emden, of Dresden, for the use of material; and Monsieur Séguy for permission to examine the types of Macquart and Robineau-Desvoidy still extant in the Paris Museum. Walker's types have been carefully examined, and the British Museum has now acquired certain of Macquart's and Bigot's types, originally in the Bigot collection. I have also had access to the material in Mr. Wainwright's collection.

HEMIPYRELLIA Tns.

Hemipyrellia Townsend, Insec. Inscit. Mens. vi. p. 154 (1918).

Genotype, *Lucilia fernandica* Macq.

A genus of wholly or partially metallic flies closely allied to *Lucilia*.

Head.—Eyes in the male closely contiguous or separated. Frons reddish brown to black. Parafrontals, face, cheeks, posterior orbits, and jowls covered with silver or golden tomentum. In female frons and parafrontals together, as seen from the vertex, about a quarter the width of head as seen from same point of view; vertex shining, slightly grey-dusted.

Thorax.—Metathorax with a bunch of upstanding hairs on the convexity above the metathoracic spiracle. Dorso-central bristles 2 + 3; acrostichals 2 + 2. Scutellum with four pairs of marginal bristles and one pair of discal bristles.

Abdomen.—Second and third visible segments may or may not have dark posterior margins. Macrochaetæ developed on hind margin of third and on fourth visible segment. Genitalia more or less prominent in male.

Legs.—Middle tibia with one antero-dorsal bristle.

Wings.—Third vein bristly almost to anterior cross-vein both above and below; subcostal sclerite bears short bristles; suprasquamal ridge with two tufts of hairs. Squamæ white.

Distribution.—Ethiopian, Oriental, and Australian Regions.

Key to Males.

- | | |
|---|-------------------------------|
| 1. Tomentum on face golden | 2. |
| Tomentum on face silver | 3. [Hebrides). |
| 2. Whole body metallic blue or green | <i>rhodocera</i> Bezzi (New |
| Thorax and abdomen partly orange | <i>fergusoni</i> Patton |
| 3. Large flies: genitalia very prominent, lateral lobes forming triangular | [(Australia). |
| heavily chitinized shields enclosing the mesolobe and paralobes; | [mas Is., Indian Ocean). |
| dorsum of thorax covered with short upstanding hairs in addition to | <i>jucunda</i> Kirby (Christ- |
| serially arranged bristles | 4. |
| Smaller flies: genitalia sometimes prominent, but not markedly so | 5. |
| 4. Eyes almost contiguous | 6. |
| Eyes separated by a distance equal to the width of the third antennal | [(Philippine Is.). |
| segment | <i>tagaliana</i> Big. |
| 5. Eyes very closely approximated, parafrontals reduced to a fine line; | [Seychelles, etc.). |
| bluish flies, the wings slightly yellow-tinged, paralobes elongate, | <i>cyanea</i> F. (Madagascar, |
| narrow, rounded apically | [Regions). |
| Eyes separated by a distance slightly less than the width of third | [ontal and Australian |
| antennal segment; shiny green or blue flies; paralobes short and | <i>lugurriens</i> Wied. (Ori- |
| broad, truncated apically, and rather heavily chitinized | 7. |
| 6. Lateral lobes elongate, testaceous, very sparsely haired; eyes separated | <i>pulchra</i> Wied. (India). |
| by a distance rather greater than width of third antennal segment, | [(Africa). |
| venter not strikingly hairy | <i>fernandica</i> Macq. |
| Lateral lobes well chitinized and markedly hairy; venter thickly | |
| haired | |
| 7. Third segment of antenna orange; eyes separated by a distance equal | |
| to the width of third antennal segment | |
| Third segment of antenna dark brown; eyes separated by a distance | |
| equal to twice the width of third antennal segment | |

Key to Females.

- | | |
|--|-----------------------------|
| 1. Tomentum on face golden | 2. |
| Tomentum on face silver | 3. [Hebrides). |
| 2. Whole body metallic blue or green | <i>rhodocera</i> Bezzi (New |
| Thorax and abdomen partly orange | <i>fergusoni</i> Patton |
| | [(Australia). |

3. Large flies: dorsum of thorax covered with short upstanding hairs in addition to the serially arranged bristles; abdomen rather tapering; posterior margins of mesopleuræ with a few golden hairs among the bristles [mas Is., Indian Ocean).
jucunda Kirby (Christ-4.
4. Smaller flies: posterior margins of mesopleuræ without golden hairs . 5.
4. Tomentum on face brilliant silver; vibrissæ hardly ascend the facialia. Tomentum on face silver-grey; vibrissæ ascend about halfway up the facialia 6.
5. Antennæ brilliant orange; abdomen heavily dusted..... *pulchra* Wied. (India).
Antennæ dark brown; abdomen lightly dusted on fourth visible segment [(Africa).
fernandica Macq.
6. Brilliantly shining green flies; vibrissæ ascend the facialia in a noticeable irregular double line; wings rather greyish [Seychelles, etc.).
Flies lightly dusted with tomentum, and therefore not so shiny; *cyanea* F. (Madagascar, [Italian Regions).
vibrissæ ascend facialia, but are less obvious 7. [ental and Aus-
7. Greenish flies: wings may be faintly tinged with yellow *ligurriens* Wied. (Ori-
Bluish flies: wings may be tinged with yellow *tagaliana* Big. (Philip-
[pine Is.).

HEMIPYRELLIA FERNANDICA Macq.

**Lucilia fernandica* Macq. Mém. Soc. Sc. Agr. et des Arts, Lille, p. 132 (1855); Dipt. Exot., Suppl. v. p. 112 (1855).

**Lucilia tæniops* Bigot (part. male), Ann. Soc. Ent. Fr. (3) vii. p. 542 (1859).

**Lucilia assiniensis* Bigot, Ann. Soc. Ent. Fr. p. 380 (1891).

Hemipyrellia curriei Tns. Insec. Inscit. Mens vi. p. 154 (1918).

Distribution.—Africa: Abyssinia, Durban, S. Rhodesia, Uganda, Mosambique, Gold Coast, Nigeria, Ashanti, Sierra Leone.

Head.—Frons narrowed but never obliterated; eyes at their nearest approach separated by a distance equal to twice the width of the third antennal segment. Parafrontals, parafacials, and jowls covered with brilliant silver tomentum, the jowls very inconspicuous and only slightly haired. Antennæ brown, reaching almost to the level of the insertion of the vibrissæ; palpi tawny to dark brown; vibrissæ hardly ascend the facialia at all. In female eyes at the vertex separated by a little more than one-fifth the width of the head.

Thorax.—Shining blue-green, somewhat dusted anteriorly in the female.

Abdomen.—Shining blue-green, with the posterior margins of the segments more or less darkened. Genitalia not very conspicuous in male, but venter with very thick bushy hairs, which are absent in the female; fourth visible segment in female lightly silver-dusted (this character is not obvious if the abdomen is at all crumpled). Male genitalia characteristic (text-fig. 1); mesolobe and paralobes narrow, compact; lateral lobes small, triangular, and very hairy; penis unusually large.

Wings.—Hyaline, somewhat greyish.

Legs.—Black.

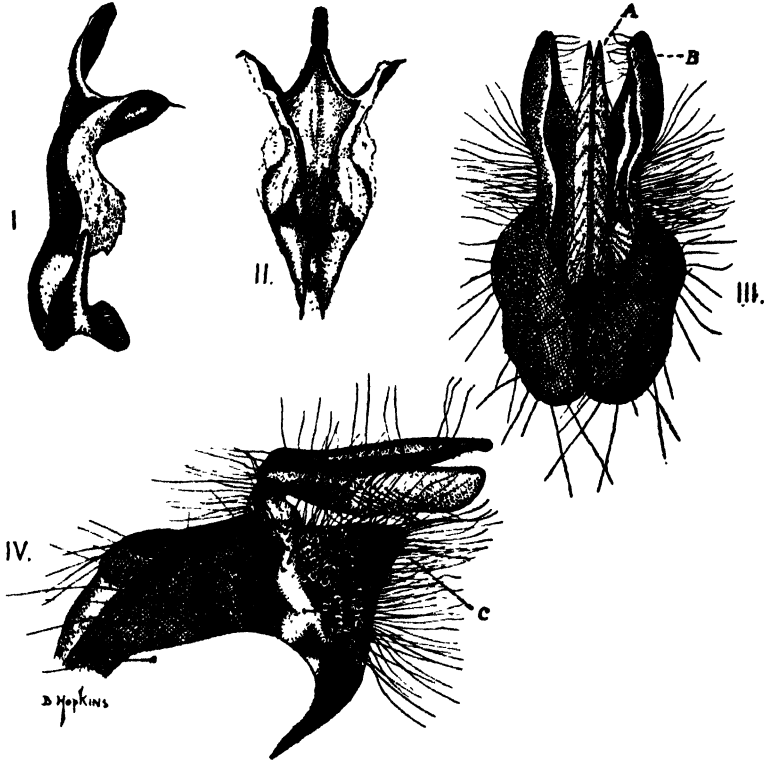
This species, the genotype, is widely spread over Africa, but has apparently not been introduced elsewhere, although the male type of *L. tæniops* Big. is supposed to be from Madagascar, and I have seen one specimen in the Paris Museum from Nionmakele, a small island off Madagascar. The type-specimens of *H. fernandica* are from Bigot's collection, and his label reads "Senegal, Fernandopo"; the published locality is "L'Amérique mérid., Fernando." This is certainly an error, although there is a Fernando River in Mexico.

Two females have recently come to my notice, one from Nigeria and one from the Sudan, which apparently belong to this species, but the antennæ

* The types of species marked thus * have been examined by the Author.

are bright orange, giving them the appearance of *H. pulchra* Wied. Unfortunately no males were taken, so that the identification remains uncertain,

Text-figure 1.



Male genitalia of *Hemipyrellia fernandica* Macq. $\times 70$.

- I. Penis, lateral view. II. Penis, posterior view. III. Hypopygium, posterior view.
IV. Hypopygium, lateral view. A = mesolobe. B = paralobe. C = lateral lobe.

but the possibility of the introduction of *H. pulchra* into Africa must be borne in mind.

HEMIPYRELLIA CYANEA F.

**Musca cyanea* F. Spec. Ins. ii, p. 439 (1781).

**Lucilia brunnipes* Macq. Mém. Soc. Sci. Agric. et des Arts, Lille, p. 295 (1843); Dipt. Exot. ii. p. 138 (1843).

**Lucilia madagascariensis* Macq. Mém. Soc. Sci. Agric. et des Arts, Lille, p. 219 (1851); Dipt. Exot., Suppl. iv. p. 246 (1851).

**Lucilia borbonensis* Macq. Mém. Soc. Sci. Agric. et des Arts, Lille, p. 220 (1851); Dipt. Exot., Suppl. iv. p. 247 (1851).

**Lucilia taeniops* Big. (part. female) Ann. Soc. Ent. Fr. (3) vii. p. 542 (1859).

**Lucilia smaragdosaphira* Big. *ibid.* p. 543.

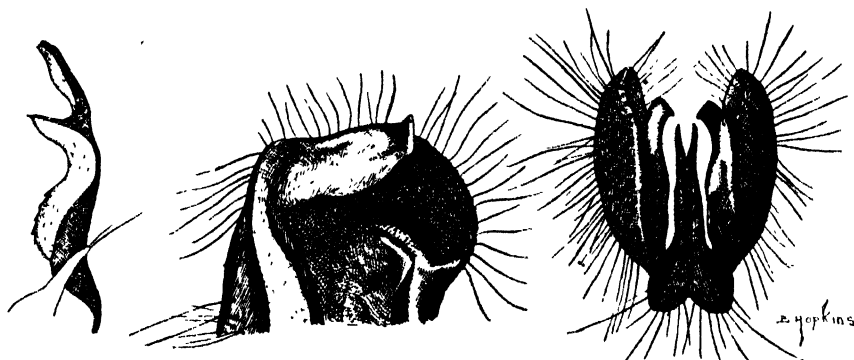
Distribution.—Madagascar, Mauritius, Seychelle Is., Reunion I.

Head.—Frons obliterated for a short space; parafrontals narrowed, separating the eyes at their nearest approach by a distance slightly less than the width of the third antennal segment. Parafrontals, parafacials, and jowls silver-grey with blackish reflections, the jowls well marked, with noticeable black hairs. Antennæ dark brown, slim, terminating some way above the mouth-border. Palpi yellow, sometimes slightly darkened at the tips. Vibrissæ ascend halfway up the facialia in a well-marked, irregular, double line. In female distance between eyes at vertex about quarter width of head, the frons narrowing anteriorly. Antennæ rather broader than in male and reaching more nearly to the mouth-edge.

Thorax.—Brilliant shining green to purple, only very slightly dusted anteriorly.

Abdomen.—Brilliant shining green to purple, the hind margins of the segments sometimes darkened; the first visible sternite and edges of the tergites with long thick-set hairs, which are not present in the female. Genitalia prominent in male, characteristic (text-fig. 2); mesolobe very short,

Text-figure 2.



Male genitalia of *Hemipyrellia cyanea* F. $\times 100$.

diverging slightly at the apex; paralobes longer than mesolobe, broad, flat, and truncated at the tips; lateral lobes well developed, black, rounded, and covered with long thick hairs.

Wings.—Hyaline, but slightly tinged with grey.

Legs.—Brown to black.

Fabricius's unique type in the Banks Collection is recorded from the Cape of Good Hope, but this almost certainly an error; it is the only record I have found of this species from the mainland. Wiedemann (1830), Macquart (1843), Stein (1913), and Malloch (1923) have used the name *Musca cyanea* F. for *Orthellia peronii* R.-D. (1830), a species allied to *O. rhingæformis* Vill., but with a less protuberant snout.

Villeneuve, on labels attached to some specimens in the Vienna Museum, established the identity of *H. madagascariensis* Macq. and *H. borbonensis* Macq., and considered *L. smaragdosophira* Big. as a synonym of *L. teniops* Big. On examining the types of *L. teniops* Big. the female proved to be identical with *H. cyanea* F., while the male was found to belong to *H. fernandica* Macq.

HEMIPYRELLIA PULCHRA Wied.

**Musca pulchra* Wied. Ausser. zweifl. Ins. ii. p. 406 (1830).

**Lucilia ruficornis* Macq. Mém. Soc. Nat. Sci. de l'Agr. et des Arts, Lille, p. 100 (1847); Dipt. Exot., Suppl. ii. p. 84, (1847).

**Musca phellia* Walk. List Dipt. Brit. Mus. iv. p. 884 (1849).

**Somomyia pagodina* Big. Ann. Soc. Ent. France (5) vii. p. 40 (1877).

Distribution.—India: N. Bengal, Pondicherry, Agra, Bihar, Coimbatore.

Head.—Eyes almost contiguous, frons obliterated at closest approximation of eyes, where they are separated by a distance equal to the width of the third antennal joint. Basal, and proximal part of second antennal segments dark brown, distal part of second segment and third segment clear orange, the latter six times as long as the former, slim, and not quite reaching the level of insertion of the vibrissæ. Parafacials and jowls silver, the latter somewhat reddish, and covered with very short inconspicuous black hairs.

Text-figure 3.

Male genitalia of *Hemipyrellia pulchra* Wied. $\times 70$.

Vibrissæ hardly ascend the facialia at all; palpi orange. In female parafrontals wider than frons, with frontal bristles rather widely spaced; upper part of frons silver-dusted; parafrontals, parafacials, and jowls markedly silvery. Third segment of antenna very clear orange, almost twice as broad as that of male, and rather longer.

Thorax.—Metallic green with purple reflections, heavily dusted anteriorly and on the hypopleuræ.

Abdomen.—Greenish to purple; sternites and edges of tergites covered with long bushy hairs. Genitalia hairy (text-fig. 3); mesolobe divergent at the tip; paralobes dilated at the base to form shining testaceous bosses; lateral lobes small, brown, triangular, and covered with long hair. In the female the hind margins of segments sometimes appear to be slightly banded; sides and fourth visible segment very heavily silver-dusted; venter without noticeable hairs.

Wings.—Hyaline; veins brown, tending to orange in the region of the second and third basal cells.

Legs.—Black.

Wiedemann, in his description of the species, does not say from what country the specimen came, but on the female which I take to be the type the label gives "Egypt" as the locality. This seems improbable, as the species

has only been recorded from India, but it must be borne in mind that the species bears a closer structural resemblance to *H. fernandica* Macq., the common African species, than to any other *Hemipyrellia* at present known. It has been recorded from Java (Senior-White, 1926), but this is probably an error arising out of faulty synonymy. Patton established the synonymy of *Musca phellia* Walk. and *Somomyia pagodina* Big.; that of *Lucilia ruficornis* Macq. was indicated by Villeneuve on a label attached to the type of *H. pulchra* Wied. Patton records that the species is larviporous, a fact which has not been established for any other species of *Hemipyrellia*. Apart from the type-specimen I have seen three females in the Vienna Museum, and one male, also in this Museum, with a female abdomen attached. The types of *L. ruficornis* Macq., *M. phellia* Walk., and *S. pagodina* Big. are in the British Museum. There is also a series of males and females labelled *L. ruficornis* Macq. in the Paris Museum.

HEMIPYRELLIA LIGURRIENS Wied.

**Musca ligurriens* Wied. Auss. zweifl. Ins. ii. p. 655 (1830).

**Musca solaia* Walk. List Dipt. Brit. Mus. iv. p. 887 (1849).

**Musca fortunata* Walk. J. Pr. L. S. iv. p. 137 (1860).

**Somomyia caeruleolimbat* Big. Bull. Soc. Zool. France, xii. p. 599 (1887).

? *Lucilia ballardii* Patton, Ind. Journ. Med. Res. ix. p. 573 (1922).

**Lucilia albopilosa* S. W. Rec. Ind. Mus. xxviii. p. 130 (1926).

? *Hemipyrellia orientalis* Tns. Suppl. Ent. xvi. p. 56 (1927).

Hemipyrellia cyaneo-marginata Mall. (nec Macq.) P. L. S. N.S.W. lii. p. 320 (1927).

Distribution.—India: Ceylon, Calcutta. Java. Celebes. China: Hong-Kong, Hankow, Foo-chow, Swatow. Philippine Is. Siam. Singapore. New Britain. Australia: Queensland. Japan.

Text-figure 4.



Male genitalia of *Hemipyrellia ligurriens* Wied. $\times 40$.

Head.—Frons much narrowed, occasionally obliterated for a short space; parafrontals narrowed, but not obviously compressed; eyes, when most nearly approximate, separated by a distance rather greater than width of third antennal segment. Parafrontals, cheeks, and jowls silver-grey, the jowls moderately well defined. Antennae tawny yellow to dark brown. Palpi orange. Vibrissae ascend about halfway up the facia in a rather irregular

row. Frons in female about the same width as both parafrontals together, although rather narrower just above the antennæ.

Thorax.—Shining green to purple, rather heavily dusted anteriorly and on the lower part of the hypopleuræ.

Abdomen.—Shining green to purple, the hind margins of the segments sometimes darkened. First visible sternite and edges of tergites with sparse, short, bristly hairs in male; male genitalia prominent and characteristic (text-fig. 4); the mesolobe diverges for a considerable distance, paralobes long, slender, and pointed, lateral lobes elongate, testaceous, and covering para- and mesolobes; the genitalia are not markedly hairy as in other species of this genus.

Wings.—Hyaline or slightly tinged with yellow.

Legs.—Black.

The species is widely spread over the Oriental and Australian Regions, and has sometimes been confused with *H. pulchra* Wied. on account of the variable colour of the antennæ; but the genitalia and comparatively wide separation of the eyes make it easily recognizable. I have seen one specimen in the Paris Museum from Japan.

The type of *M. solaia* Walk. is a female, and no locality is given, but it undoubtedly belongs to this species. The type of *M. fortunata* Walk. is a male from Macassar. *Somomyia cæruleolimbata* Big. from Java was unfortunately synonymized with *H. pulchra* by Patton (Senior-White, 1926), but the specimens certainly belong to *H. ligurriens* Wied.; it is doubtful if *H. pulchra* Wied. will be found so far south. The types of *Lucilia albopilosa* S. W. agree very well with the type of *H. ligurriens*, but the series of paratypes which I have examined contains some males of *Lucilia metilia* Walk., and the genitalia figured in the description are unfortunately taken from one of these specimens. Macquart's species *L. cyaneo-marginata* is a synonym of *Lucilia papuensis* Macq., Malloch (1927) having employed the name erroneously for *H. ligurriens* Wied.

HEMIPYRELLIA TAGALIANA Bigot.

**Somomyia tagaliana* Big. Ann. Ent. Soc. Fr. (5) vii. p. 44 (1877).

Distribution.—Philippine Is.; Lombok.

Head.—*Male*. Eyes almost contiguous, frons obliterated and parafrontals reduced to a fine line; parafacials and jowls covered with grey tomentum, the latter with inconspicuous black hairs. Vibrissæ ascend facialia for one-third their total length. Antennæ dark brown; palpi orange.

Thorax.—Metallic blue-green.

Abdomen.—Metallic blue-green, the hind margins of the segments somewhat darkened. First visible sternite and edges of tergites with bunches of long coarse bristles. Genitalia hairy, the mesolobe and paralobes compact, the latter testaceous at the tips; lateral lobe well developed, oval, with long fine hairs (text-fig. 5).

Wings.—Hyaline, but tinted greyish brown.

Legs.—Black.

I have seen the single male type, one male specimen in the Vienna Museum, and one male and a series of females in the possession of Mr. Wainwright, and consider that this is the species referred to by Malloch (1926) under the name "*? fortunata*" Walk.; this latter species, is however, a synonym of *H. ligurriens* Wied. I have been unable to find any satisfactory character for separating the females of *H. tagaliana* Big. and *H. ligurriens* Wied.; the colour difference used by Malloch may be a guide, but it is too unreliable for purposes

of identification. Among the females which may belong to *H. tagaliana* Big. is the type of **Lucilia nesiotis* Schin., placed by Patton (1925) in synonymy with *L. nosocomiorum* Dol., a true *Lucilia*. This specimen was taken on

Text-figure 5.

Male genitalia of *Hemipyrellia tagaliana* Big. $\times 70$.

Pelew Is., east of the Philippine Is. ; other specimens which I suspect of being *H. tagaliana* Big. were captured at Singapore and on the Philippine Is.

HEMIPYRELLIA JUCUNDA Kirby.

**Stilbomyia jucunda* Kirby, Proc. Zool. Soc. p. 555 (1888).

Distribution.—Christmas Is. (Indian Ocean).

Head. Frons not obliterated although narrowed ; distance between the eyes at point of closest approximation equal to twice the width of third antennal segment. Parafrontals, parafacials, and jowls silver-grey, vibrissae ascending halfway up the facialia ; jowls covered with obvious black hairs. Antennae brown ; palpi orange. In female distance between eyes at vertex one-quarter width of head.

Thorax.—Metallic green, slightly dusted anteriorly and on pleurae. Dorsum covered with coarse upstanding hairs, apart from the serial bristles. Posterior margin of mesopleura with a few fine golden-brown hairs among the bristles.

Abdomen.—Metallic green, thinly dusted, the posterior margins of the segments darkened. Sternites in male covered with long golden hairs and edges of tergites with sparse long black bristles. Genitalia very prominent (text-fig. 6) ; lateral lobes developed into heavily chitinated triangular shields which completely enclose the mesolobe and paralobes.

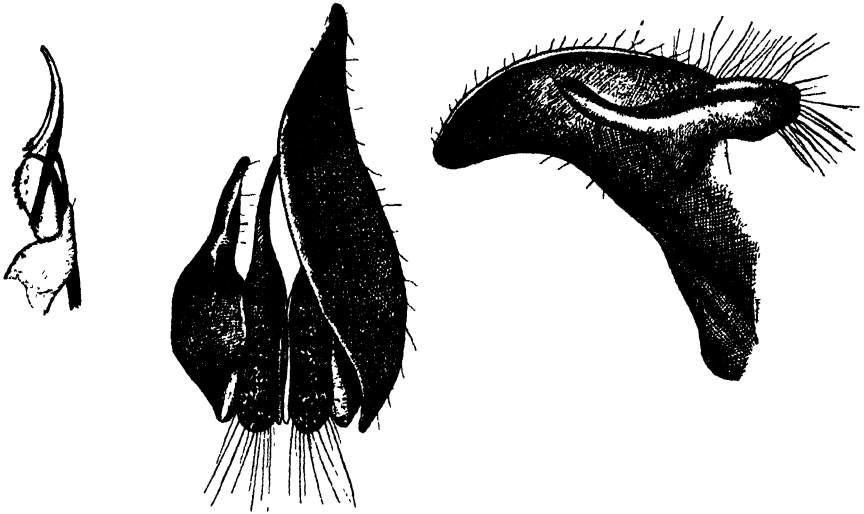
Wings.—Hyaline, greyish.

Legs.—Dark brown to black.

The species was described by Kirby from six female specimens brought back from Christmas Is. (Indian Ocean) by Sir J. J. Lister in 1887 ; it was not listed in Vann der Wulp's 'Catalogue of the Diptera of Southern Asia,' and, as far as I can discover, has not been described under any other name since. A male in the British Museum, collected from Christmas Island in 1904, has enabled me to place the species in the correct genus and figure the genitalia.

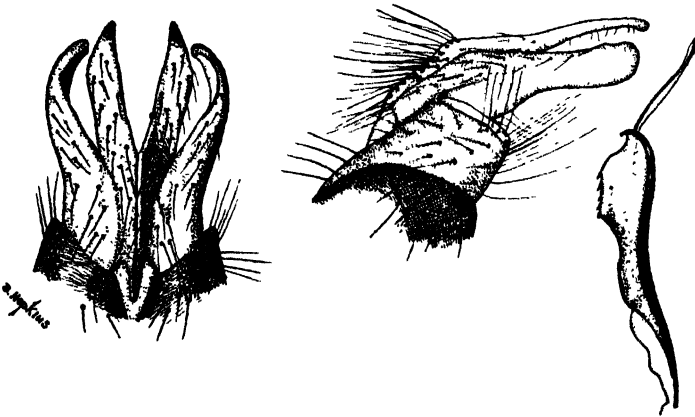
It appears to be an endemic species and is a characteristic *Hemipyrellia*, but the prominence of the genitalia indicate an affinity with Townsend's genus

Text-figure 6.

Male genitalia of *Hemipyrellia jucunda* Kirby. $\times 45$.

Hypopygiopsis, which is common in Malay; this genus is distinct from *Hemipyrellia* on account of the greater size and the development in the male of thickened femora and very hairy legs.

Text-figure 7.

Male genitalia of *Hemipyrellia rhodocera* Bezzi. $\times 70$.

HEMIPYRELLIA RHODOCERA Bezzi.

Lucilia (Hemipyrellia) rhodocera Bezzi, Bull. Ent. Res. xvii. p. 237 (1927).

Distribution.—Samoa, Fiji.

A full description is given by Bezzi, and I can only add a figure of the

genitalia (text-fig. 7), which differ from those of the other species of the genus in that the lateral lobe is not very strongly developed and does not hide the paralobes. The type-specimen is lightly chitinized, and the genitalia appear to be testaceous, bearing rather scant long brown hair on the lateral lobes, base of mesolobe, and paralobes. The species is easily recognizable on account of the closeness of the eyes, slight enlargement of the upper eye-facets in the male, and the golden tomentum on the jowls. Apart from the type-specimen I have seen a single male in the Vienna Museum, determined by Malloch, from Fiji; the species is not recorded from this locality by Bezzi (1928) in his description of the Diptera of these islands.

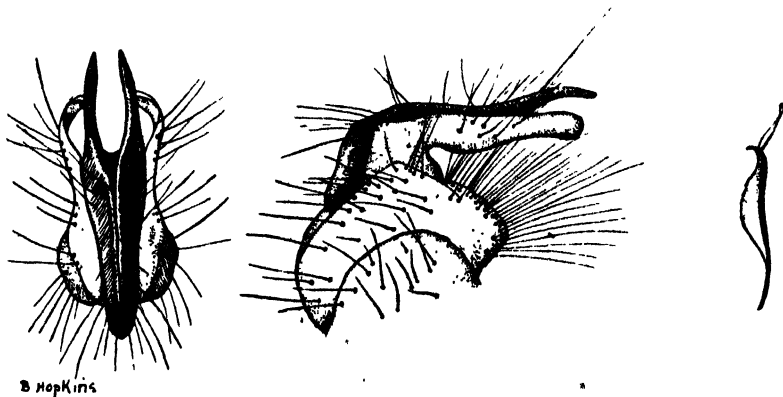
HEMIPYRELLIA FERGUSONI Patton.

Lucilia fergusoni Patton, Phil. Journ. Sc. xxvii. p. 403 (1925).

Distribution.—Australia.

This Australian species has been recognized as a *Hemipyrellia* by Malloch (1927). The general colouring and chaetotaxy are adequately described by Patton, but one or two notes may be added from specimens which I have examined from Brisbane. The hypopleura and lower part of the sternopleura

Text-figure 8.



Male genitalia of *Hemipyrellia fergusoni* Patt. $\times 50$.

are dark, but heavily dusted with golden tomentum; the thoracic pubescence is largely golden, noticeably the tuft of hairs on the convexity above the posterior thoracic spiracle; the thoracic spiracles are white, an unusual feature in this group; the basicostal scale of the wing is orange, and, as Malloch has already noted, the bristles on the subcostal sclerite are golden.

The hypopygium (text-fig. 8) is testaceous and bears a strong resemblance to that of *H. rhodocera* Bezzi. These two species appear to be closely allied, and constitute such a marked contrast to the remaining species in the genus that, when the Australian fauna is better known, it may be advisable to erect a fresh genus for their reception.

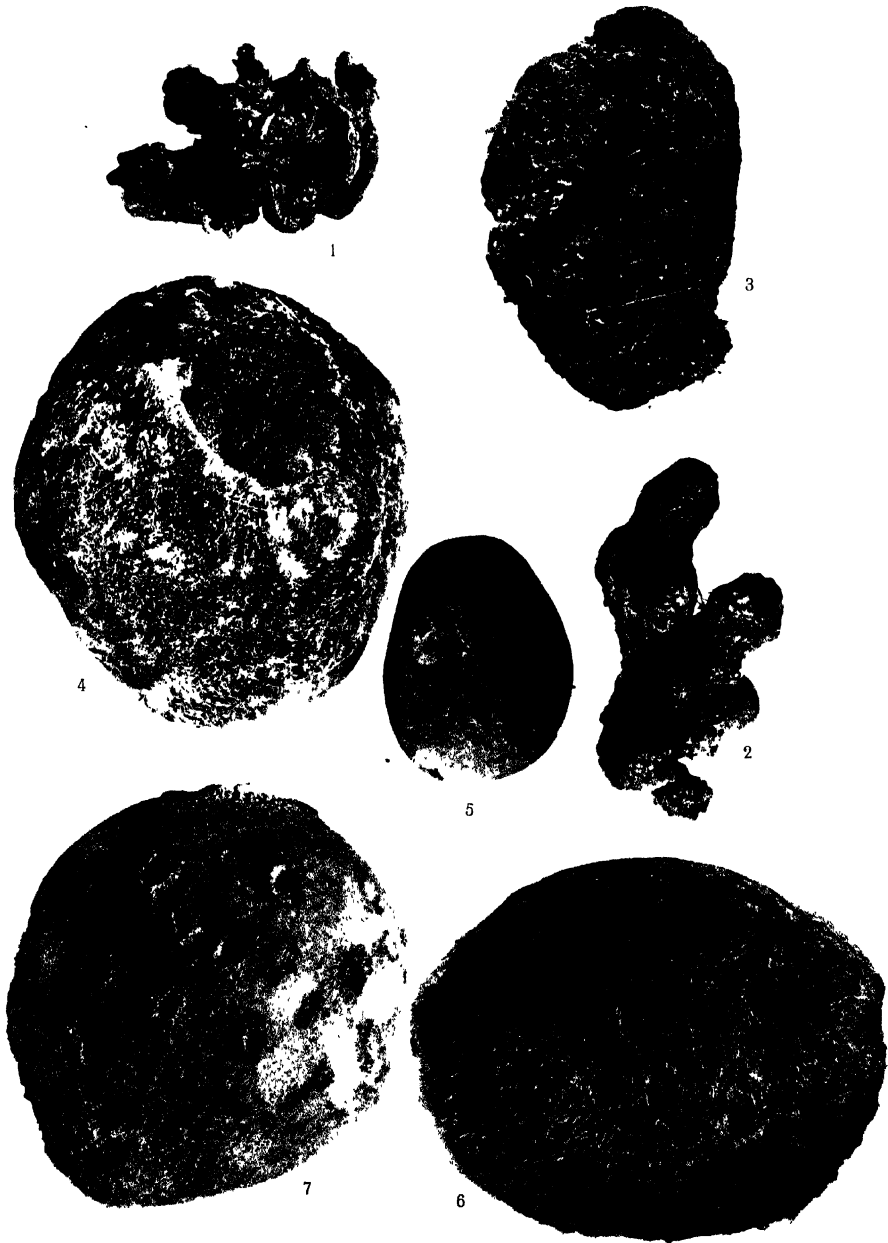
LIST OF PAPERS REFERRED TO IN TEXT.

BEZZI, M. 1928. Dipt. Fiji, B. M. London.

MACQUART, J. 1843. Dipt. Exot. ii. pt. 8, p. 145.

MACQUART, J. 1855. Mém. Soc. Sci. Agric. Arts, Lille, p. 302.

- MALLOCH, J. R. 1923. *Ann. & Mag. Nat. Hist.* (9) xii. pp. 510, 516
MALLOCH, J. R. 1926. *Ibid.* p. 505
MALLOCH, J. R. 1927. *Proc. Linn. Soc. N.S.W.* lii. p. 302.
MALLOCH, J. R. 1929. *Ann. & Mag. Nat. Hist.* (10) iv. p. 120.
PATTON, W. G. 1925. *Phil. Journ. Sc.* xxvii. p. 404.
ROBINEAU-DESVOIDY, A. J. B. 1830. *Myodaires*, p. 460.
SEANNON, R. C. 1924. *Ins. Insc. Mens.* xii. p. 68.
STEIN, P. 1913. *Ann. Mus. Hung.* xi. p. 474.
TOWNSEND, C. H. T. 1918. *Ins. Insc. Mens.* vi. p. 154.
SENIOR-WHITE, R. 1926. *Rec. Ind. Mus.* xxviii. p. 130.
WINDEMANN, C. R. W. 1830. *Ausser. Zweifl. Tns.* ii. p. 397.



EMBRYONIC AND POST-LARVAL CHARACTERS OF CERTAIN

27. The Interpretation of the Embryonic and Post-larval Characters of certain Tetraxonid Sponges, with Observations on Post-larval Growth-stages in some Species. By MAURICE BURTON, M.Sc., F.Z.S., Assistant-Keeper in the Department of Zoology, British Museum (Natural History).

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(Plate I.*; Text-figures 1-6.)

Little is known of the post-larval growth of sponges or of the morphological and anatomical changes involved therein. In a few species our knowledge of the development from the egg to the fixation of the larva is extensive, but what takes place after this is unknown. Systematists have, it is true, occasionally suggested that the differences between two supposed species may be due to differences in age, but hitherto we have had no positive proof of this. Certain observations made during the past few years seem to shed considerable light on this question, and suggest that important and marked changes take place subsequently to the fixation of the free-swimming larva. This means that, in addition to the four known stages in growth—embryonic, larval, post-larval, and adult stages—the last-named must, in some cases, be further subdivided. In one species at least three distinct growth phases following that represented by the fixation of the larva and its metamorphosis can be demonstrated. The metamorphosis, and the encrusting stage succeeding it, will be referred to henceforth as the post-larval period, and the three subsequent stages, for want of better terms, as the juvenile, mature, and senescent stages respectively. The term adult is scarcely applicable, since it would apply equally to the two last stages; and since the last of these represents the final stage of growth, and is probably the one that immediately precedes the death of the individual, the term senescent is not wholly inappropriate.

Doubtless in many cases the differences between the three stages succeeding the post-larval stage are less well marked than in the species here described. In some, again, they may be entirely unrecognizable, but because they do occur in some species, and because the recognition of their occurrence must have inevitably a far-reaching effect on the systematic study of the group, it is important that due attention be paid to these features.

With few exceptions sponges pass through four well-marked stages in their life-history, which can, and have been, universally recognized, and for purposes of comparison it will be necessary to recapitulate briefly the known facts connected with them. The embryonic stage is passed in the maternal tissues, and includes the fertilization of the egg and its segmentation to form a spherical or subspherical embryo. This is followed by a free-swimming larval period, in which the only changes from the embryonic state are, as a rule, a slight change in shape and the development of a coating of cilia on the outer surface. The larval period lasts normally some twenty-four hours, and is followed by a metamorphosis resulting in the formation of a small thin incrusting sponge. This stage may last for several weeks with little alteration in size or shape, but is succeeded by a period of renewed activity and vigorous growth. Spicules

* For explanation of the Plate, see p. 525.

may appear at any time, from the inception of the embryo to the post-larval period, according to the species. Subsequent growth has always been assumed to be uniform, with little alteration in either the gross or the microscopic anatomy, but in the following notes it will be shown that this is not invariably the case. The observations noted are made on a few species only but it is probable that further research may reveal the same series of changes in numerous other species.

DEVELOPMENT IN CERTAIN SPECIES OF TETRAXONIDA.

(i) *IOPHON RADIATUS* Topsent. (Text-figs. 1 & 2.)

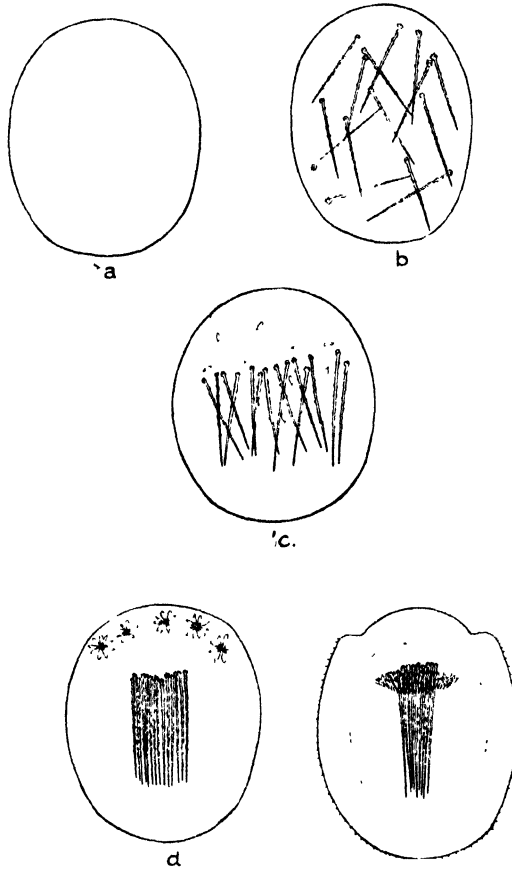
Several specimens have come to hand recently having numerous embryos enclosed in well-developed capsules within the maternal tissues, and from these it is possible to reconstruct the probable sequence of events in the pre-larval development of *Iophon radiatus*. It appears that the embryo is at first roughly spherical and aspiculous, and that it continues in this state until a size of .3 mm. diameter is reached (text-fig. 1, *a*). Subsequent changes involve little alteration in size or shape or in the appearance of the component cells, and the only visible signs of development are in the appearance and arrangement of the spicules. The first of these to appear are small slender acanthostyli, which are at first scattered without order in the embryonic tissues (text-fig. 1, *b*). At the next stage they show a tendency to aggregate in the centre of the embryo along its long axis, uniformly orientated, with the basal or stylote end of the spicule pointing towards the aboral pole of the embryo (text-fig. 1, *c*). Concurrently with the rearrangement of the acanthostyli, anisochelæ make an appearance, scattered indiscriminately around the aboral half of the bundle of acanthostyli. At the next stage the acanthostyli become more definitely and closely arranged in a bundle, and the anisochelæ congregate in rosettes near the aboral pole of the embryo (text-fig. 1, *d*). In the last stage the anisochelæ migrate back and form a ring around the aboral end of the bundle of acanthostyli. Simultaneously with this the embryonic cells become differentiated into an inner mass of large granular cells, somewhat irregular in outline and darkly coloured, and an outer layer of smaller non-granular cells. In addition a well-marked aboral area is formed similar to that observed in the free-swimming larvæ of other species, and this, together with the finding of traces of cilia on the outer layer of cells, suggests that at this stage the embryo is liberated (text-fig. 1, *e*).

Nothing at all is known of the larval stages in this species, but a good series of specimens in the British Museum collection, supplemented by the published descriptions of other individuals, has made it possible to trace the growth from the post-larval stage to what is probably an adult of maximum size.

In order to understand the post-larval history it will be necessary to recapitulate the history of the species. Until two years ago five species and two varieties of *Iophon* had been described from the Antarctic, but in 1929 I proposed that these should be regarded as constituting a single species only. In so doing I was influenced by the general likeness between the various individuals described under the different specific names, and the fact that the embryos in the only two specimens in which they occurred showed similarities in structure. These two specimens were described by Kirkpatrick as *I. radiatus* Topsent and *I. spatulatus*, sp. n., and their embryos were figured. But although these figures showed great differences between the embryos, I have found on re-examination of his preparation that they are inaccurate and that the same

types of spicules are present in each case (text-fig. 2, a). On re-examining the material then at my disposal, together with that since acquired, it has become apparent that the differences between these supposed species and varieties, which I had regarded as due to mere fluctuating variations, have a special significance. The salient features of the various individuals assigned

Text-figure 1.



Successive stages in the development of an embryo of *Iophon radiatus*
Topsent. (Semi-diagrammatic.)

In e the cilia are merely suggested, as traces only of them were found in the preserved material from which this drawing was made.

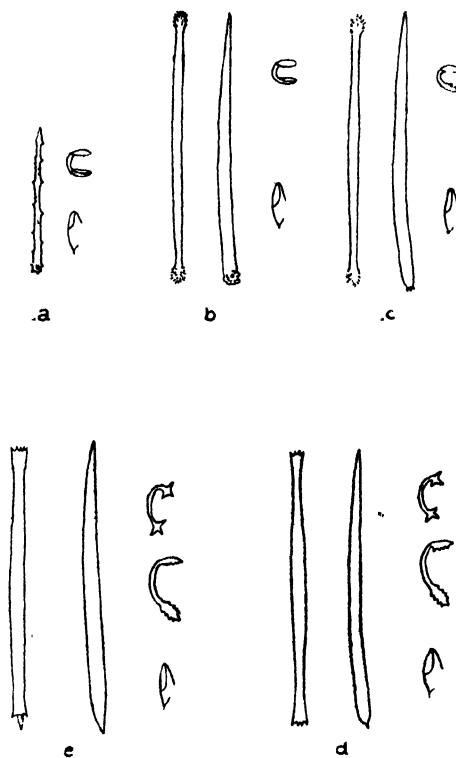
to these "species" and "varieties," which I considered to be synonyms of *I. radiatus*, are set forth in the accompanying table (see p. 516).

There is one point in connection with the table which requires explanation. With regard to *I. unicornis* (7) and *I. aceratus* (1) the respective authors leave a doubt as to the nature of the dermal skeleton. Topsent (1908, p. 28) states that the tornota are "épars ou fasciculés, toujours tangentiels." This is very often the effect seen when sections are cut from individuals in which

the dermal skeleton is composed of tufts of tornota set at right angles to the surface and examined in a certain way. Similarly Hentschel (1914, p. 88) states that the tornota in *I. aceratus* are predominantly tangential, and the same remark probably applies there. Not having seen the specimens it is not possible to be certain of the correct interpretation of these remarks, but from experience I infer that the dermal skeleton was actually in tufts.

Of the spicules the dimensions only are indicated in the table. This is to show that the differences between the various individuals in this respect

Text-figure 2.

*Iophon radiatus* Topsent.

Spicules from *a*, an embryo; *b*, post-larval stage; *c*, juvenile stage; *d*, mature stage; and *e*, senescent stage.

are such as may be expected from the normal fluctuations in the size of spicules recognized in allied species. The presence or absence of one or more of the microscleres is a negligible point, since it has been demonstrated in a single species such as the well-known *I. pattersoni* (Bowerbank).

Passing now to the shape of the spicules, we find that in 1 the tornota have oval and entirely-spined heads, the styli are basally tuberculate, and the bipocilla are saucer-shaped at each end. In 2 and 3 the tornota are the same as in 1, the styli are basally spined, and the bipocilla cup-shaped at one end and toothed at the other. In 6 the tornota have truncated and serrated ends, the styli are smooth and basally mucronate, and the bipocilla toothed

at each end. The bipocilla are absent in 7 and 8, but the rest of the skeleton corresponds with that of 6. In 9 the styli are the same as in 6, 7, and 8, but the mucron at the base is more strongly developed, the tornota are similar but bear, in addition, a mucron at one end, and the bipocilla are still toothed. The same is true for 10 and 11, except that in the latter the styli are modified to form pseudoxea.

The individuals represented in the table fall thus into four groups, as follows :—

Group I.—1. Tornota with oval entirely-spined heads; styli basally tuberculate; bipocilla saucer-shaped at each end; dermal skeleton tangential; specimen small and encrusting (text-fig. 2, b). (= Post-larval stage.)

Group II.—2 and 3. Tornota with oval entirely-spined heads; styli basally spined; bipocilla saucer-shaped at one end and toothed at the other; dermal skeleton tangential; size up to but not exceeding 5 cm. high (text-fig. 2, c). (= Juvenile stage.)

Group III.—6, 7, and 8. Tornota with truncate and serrated ends; styli smooth, basally mucronate; bipocilla toothed at each end; dermal skeleton in tufts set at right angles to surface; size of specimen from 6–10 cm. high (text-fig. 2, d). (= Mature stage.)

Group IV.—Tornota truncate and serrated at one end, serrated and mucronate at the other; bipocilla toothed at each end; dermal skeleton in tufts set at right angles to surface or else absent; size of specimens 10 cm. or more high (text-fig. 2, e). (= Senescent stage.)

It will be necessary first of all to make sure that these four groups do not represent merely four species, or four subspecies or varieties of a single species, and to do this intermediates must be sought in which the transition from the characters of one to those of another may be demonstrated. Actually these are forthcoming, and the evidence they afford is convincing. In 5 are to be found a mixture of the characters of Groups II. and III. In this specimen both sorts of tornota and styli are present, but the dermal skeleton still remains tangential. Comparing this with 3 and 4, it is seen that the three specimens form a fairly complete series of transitional stages from the juvenile to the mature stages. Specimens 3 and 4 are about the same size, have a similar form, and in both the dermal skeleton is tangential, but while in 3 the form of the spicules is characteristic of Group II., in 4 it is characteristic of Group III.

In order to test the validity of this explanation of the differences in the various individuals tabulated above, efforts have been made to obtain as many representatives of the genus from the Antarctic as possible in addition to those referred to in the table on p. 516. The results of the examination of material so obtained are highly satisfactory.

The first two specimens have the skeletal characters of Group II., the first being 1 cm. and the second 5 cm. high. In the third specimen, with skeletal characters of Group III. and measuring 7 cm. high, the dermal skeleton is tangential but sparse. This suggests at once that a rearrangement of the dermal skeleton is taking place, and that while the size and the form of the spicules are normal for Group III., the change in the character of the dermal skeleton is slightly lagging. The next three specimens are 8 or more cm. high, but, being incomplete, it is more than probable that the total size in life was the 10 cm. or more characteristic of Group IV.

Two more specimens deserve special notice since they seem to clinch the argument in favour of interpreting the supposed specific differences as evidences of growth stages. Both are about 3 cm. high, with the skeletal characters of Group II., but in each the dermal skeleton is clearly changing from the

TABLE OF ANTARCTIC SPECIES OF *IOPHON*.

| Species. | Author. | Size and shape of specimen. | Tornota in mm. | Styli in mm. | Large anisochela in mm. | Small anisochela in mm. | Bipocilla in mm. | Dermal skeleton. |
|--|---------------------|------------------------------------|----------------|--------------|-------------------------|-------------------------|------------------|--|
| 1. <i>radiatus</i> | Topsent (1901). | 3 × 2 × 2 mm., encrusting. | .4 | .58 | .07 | .017 | .016 | |
| 2. <i>pluricornis</i> var. <i>trullifera</i> . | Hentschel (1914). | 2 cm. across; encrusting. | .33 | .4 | .03 | .014 | .011 | |
| 3. <i>radiatus</i> | Kirkpatrick (1908). | 5 cm. X 4 mm; erect, cylindrical. | .27 | .48 | .036 | .02 | .01 | } tangential. |
| 4. <i>spatulatus</i> | Kirkpatrick (1908). | 5 cm. X 4 mm.; erect, cylindrical. | .225 | .46 | — | .018 | .015 | |
| 5. <i>pluricornis</i> | Topsent (1908). | 10 cm. X 5 mm.; encrusting. | .28 | .4 | .03 | .014 | .011 | |
| 6. <i>flabello-digitatus</i> var. <i>gouessi</i> . | Hentschel (1914). | 6 cm. high; massive. | .27 | .38 | .03 | .017 | .016 | |
| 7. <i>unicornis</i> | Topsent (1908). | 7 cm. X 4 cm.; massive. | .24 | .47 | .02 | .018 | — | |
| 8. <i>unicornis</i> | Hentschel (1914). | 10.5 cm. high; massive. | .32 | .58 | .024 | .02 | — | } in tufts at right angles to surface. |
| 9. <i>flabello-digitatus</i> | Hentschel (1914). | 40 cm. high; flabello-digitate. | .4 | .7 | .035 | .017 | .02 | |
| 10. <i>flabello-digitatus</i> | Kirkpatrick (1908). | 26 cm. high; massive. | .34 | .59 | .035 | .025 | .011 | |
| 11. <i>aceratus</i> | Hentschel (1914). | 2.5 cm. across; massive. | .4 | .64 | .024 | .017 | .013 | |

tangential to the condition of radial tufts. That is, while some tornota are arranged tangentially to the surface the majority are arranged in tufts at right angles to it. Further, and this seems to be the most convincing piece of evidence, on searching the more internal tissues of the two sponges a few smooth, mucronate styli, characteristic of Group III., were found.

Clearly more material is desirable for corroborative examination, but it seems to be beyond dispute that the differences in size of the various specimens already discussed are to be correlated with changes in both the form of the spicules and the structure of the dermal skeleton, and that these changes correspond to well-marked growth phases.

The results of these observations may be summarized as follows :—Subsequent to the fixation of the larva, growth in *Iophon radiatus* Topsent is accompanied by definite and continuous (or periodic ?) changes not only in the size of the individuals, but also in the form and arrangement of the spicules. The changes in the skeleton coincide approximately, and seem to occur when the individual has attained a certain size. The changes in the form of the spicules include the transition from: *a*, basally-spined styli, to smooth, basally-mucronate styli, or even pseudoxea; *b*, tornota with oval entirely-spined heads to tornota with truncate and serrated ends, these being replaced in turn by tornota with one end truncate and serrated and the other serrated and mucronate; and *c*, bipocilla with both ends saucer-shaped to both ends toothed. In regard to the bipocilla, it is of interest to note that in rare cases these spicules appear in the embryo while still within the maternal tissues, and that in such cases they are always saucer-shaped at each end. The change in the arrangement of the spicules involves only the tornota, and consists of a transition from a tangential arrangement of the spicules to their arrangement in tufts at right angles to the surface. In the very large specimens a dermal skeleton cannot always be distinguished, the tornota being distributed among the meshes of the main skeleton.

Although it cannot be definitely ascertained it would appear that sexual maturity coincides approximately with the later half of the juvenile stage, or perhaps it is that the changes involved in the transition from the juvenile to the mature stages are closely connected with the attainment of sexual maturity. At all events, the only specimens found containing embryos were at the stage immediately preceding the loss of the tangential dermal skeleton.

Several other points may be inferred from these observations of the pre-larval and post-larval growth stages in the species. In the first place, it can now be accepted beyond question that a continuous or periodic extrusion of spicules takes place in some siliceous sponges, and probably in all. Secondly, if the Recapitulation Theory holds true, the styli, since they are the first to appear in the embryo, may be regarded as the most primitive spicules in this particular association, and the bipocilla, which arise last, as the least primitive. Moreover, since the first spicules to arise in the embryo are acanthostyli, and these give place to smooth styli and eventually pseudoxea, the acanthostyli may be regarded as more primitive than the smooth styli. Finally, assuming this point to be correct, it is clear that the Antarctic species of *Iophon* is the most specialized in the genus.

A final point, and one of some consequence, concerns the form described by Hentschel as *Iophon aceratus*. Some fifteen specimens of this were found, none of them more than 2.5 cm. across. In the table given on p. 516 this species is given last, at the end of a series of increasing size. Actually this is the correct place for it, as other specimens showing the same skeletal features are large, and there is no reason to doubt that this form does actually represent the

ultimate stage of growth in the species. That Hentschel's specimens were all small may be interpreted as a case of arrested development, and while the changes involved in the progression from one growth stage to another are normally accompanied by gradual increase in size of the sponge, it is easy to conceive of conditions under which, either from scarcity of food or other factors, growth is inhibited, and the various stages are passed without increase in size.

(ii.) *MYXILLA ELONGATA* Topsent. (Pl. I. figs. 2 & 3.)

The embryonic and larval stages of *Myxilla elongata* are unknown, and the species has been recorded hitherto on two occasions only. There are, however, in the British Museum collection some nine specimens which from general appearance seem to belong to this species. Two of them are small, 3 and 5 cm. high respectively, and the rest considerably larger. The differences between these two groups, the large and the small specimens, are of such a nature that, but for the analogy afforded by *Iophon radiatus*, it would have been necessary to regard them as representing two distinct species, or at least as two subspecies of a single species. In the light of the observations made on *Iophon radiatus* it is, however, clear that the two groups represent the juvenile and mature stages of a single form, and because of the similarity of the changes which mark the transition from the one stage to the other with those seen in *Iophon radiatus*, it is of interest to describe them briefly.

Such a description is best shown in the following table :—

| Juvenile. | Mature. |
|---|--|
| Sponge small, irregularly lobose, 3 to 5 cm. high. | Sponge erect, with deep cloacæ opening by conspicuous oscules at the summits of cylindrical lobes, 7 cm. or more high. |
| Main skeleton composed of a network of acanthostyli, echinated at the nodes by much smaller acanthostyli. | Skeleton as in juvenile form, but without echinating acanthostyli. |
| Tornota arranged in a tangential layer at surface. | Tornota arranged in tufts at right angles to surface. |

The smallest of the large specimens, while agreeing in all other respects with the rest of the large specimens, is intermediate between the juvenile and the mature forms in that the dermal skeleton consists of a tangential layer of tornota with tufts of tornota assembled beneath it.

It is also of interest to note that similar changes, differing from those observed in *M. elongata* in small details only, may be observed in a series of specimens of *M. mollis* Ridley and Dendy, so that it is probable that the growth stages found in the species of *Iophon* may be a regular feature of many species of *Myxilla* also.

The change from the juvenile to the mature condition in *Myxilla mollis* is marked by a change in the external form and in the dermal skeleton, and by the loss of echinating acanthostyli. In this it differs from the condition found in *Iophon radiatus*, where the whole spiculation undergoes a change. At the same time it is possible that more abundant material of the first species may shed further light on this and cause a revision of this statement. The conclusions to be drawn from the observations made on *Myxilla mollis* are none the less of special significance. The presence of echinating acanthostyli in the juvenile

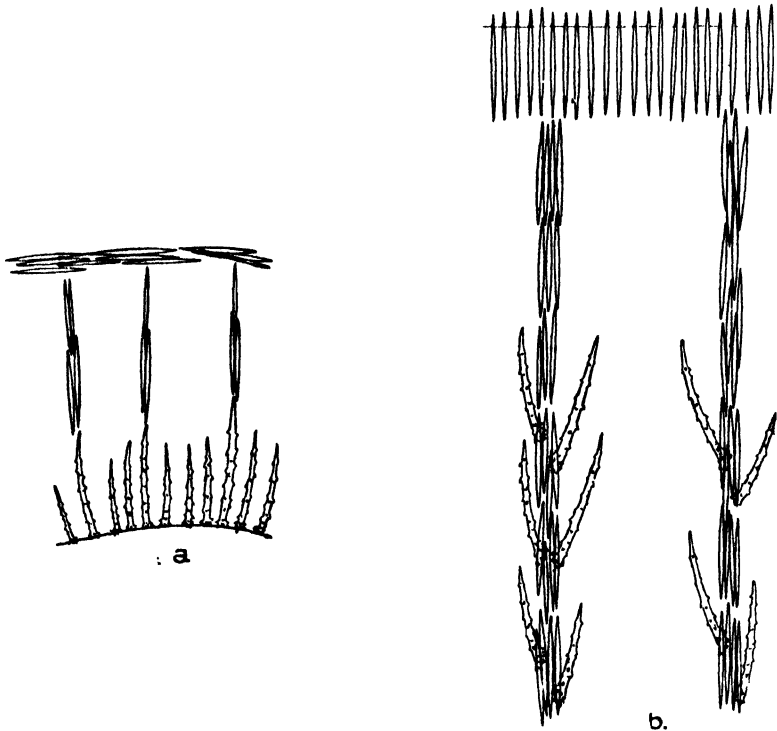
form and their absence in the mature form suggest that they represent a primitive feature, certainly one peculiar to early stages of this particular species, and it is even probable that they represent the larval or post-larval spicules which persist into the juvenile stage as accessories to the main skeleton of that stage. It would explain why echinating acanthostyli are occasionally found in some individuals of other species of *Myxilla* which do not normally possess them.

The suggestion made that the Antarctic species of *Iophon* are probably specialized seems to be true also of the species of *Myxilla* from the same region.

(iii.) *HYMEDESMIA AREOLATA* Thiele. (Pl. I. fig. 1 ; text-fig. 3.)

The sponge originally assigned to this species forms a thin incrustation on some chitinous tubes less than 2 mm. thick. The skeleton consists of acanthostyli of two sizes echinating the walls of the tubes, and from this basal layer of spicules arise strands of tornota running vertically to the surface.

Text-figure 3.



Skeleton of *Hymedesmia areolata* Thiele.

As seen in radial section ; a, juvenile ; and b, mature stages. (Semi-diagrammatic.)

The dermis is strengthened by a tangential layer of similar tornota. The microscleres are isochelæ. This specimen is therefore a typical *Hymedesmia* (text-fig. 3, a).

The second specimen, recorded by Kirkpatrick (1908, p. 24), is massive and 12 cm. high. The external appearance is similar to that of the type of the

species, but the arrangement of the skeleton is markedly different. The inner tissues are supported by a well-developed but irregular network of bundles of tornota sparsely echinated by acanthostyli, but at a little distance from the surface the latter disappear and the bundles of tornota run vertically to the surface without any sign of echinating spicules (text-fig. 3, b). The dermal skeleton consists of a dense palisade of tornota set at right angles to the surface. This specimen would therefore have been better placed in the genus *Anchinoë*.

At first sight the two specimens described above appear to belong to distinct genera, but because of the similarity between them in the appearance of the surface, the character of the pores and oscules, the types of spicules present, and other smaller details of their anatomy, this cannot be the case. All the same, it was difficult to reconcile the differences between the two specimens with their inclusion in a single species, but as a result of the study of *Iophon radiatus* it is evident that they are truly conspecific and that we have here yet another case of a series of growth changes. The species must be known as *Anchinoë areolata*.

In the British Museum collection are three more specimens which agree in all but the arrangement of the skeleton with the two specimens described above, and it is significant that in each of these the dermal skeleton differs from that of the type and of Kirkpatrick's specimen. In the first, of similar size to the type, a tangential dermal skeleton is present, and in addition there are indications of the formation of a vertical palisade. The second, 2 cm. high, is irregularly lobose, and though the dermal skeleton is predominantly the same as in the type, the traces of a former tangential skeleton are less marked. The third, obtained by the Shackleton-Rowett Expedition, is 3.5 cm. high, and the dermal skeleton is very much the same as that of Kirkpatrick's specimen, but still shows traces of a former tangential skeleton. Thus in these three specimens we have a well-graded series showing the gradual loss of the tangential dermal skeleton and the appearance of a dermal palisade, and this corresponds approximately with a gradual increase in size.

In *Anchinoë areolata* we have a similar state of affairs to that found in *Iophon radiatus*, but instead of the post-larval and juvenile stages being clearly marked off, there appears to be little difference between them except in size; or else it is that the post-larval stage persists for a longer time. In this case the stage here regarded as the mature stage would be the juvenile stage, and it is necessary to await more material to know whether any further changes in the skeleton take place.

From the study of this very scanty material several conclusions are reached. In the first place the genus *Hymedesmia* is clearly, with a few exceptions which have been shown to be permanently encrusting, a heterogenous collection of post-larval stages of many species of Myxillæ, and possibly of a few Clathriæ too. The section *Hymedesmiæ* must therefore be abandoned. Secondly, it will be necessary to reconsider all genera characterized by an encrusting habit, and see how far they may be regarded as post-larval forms of other genera.

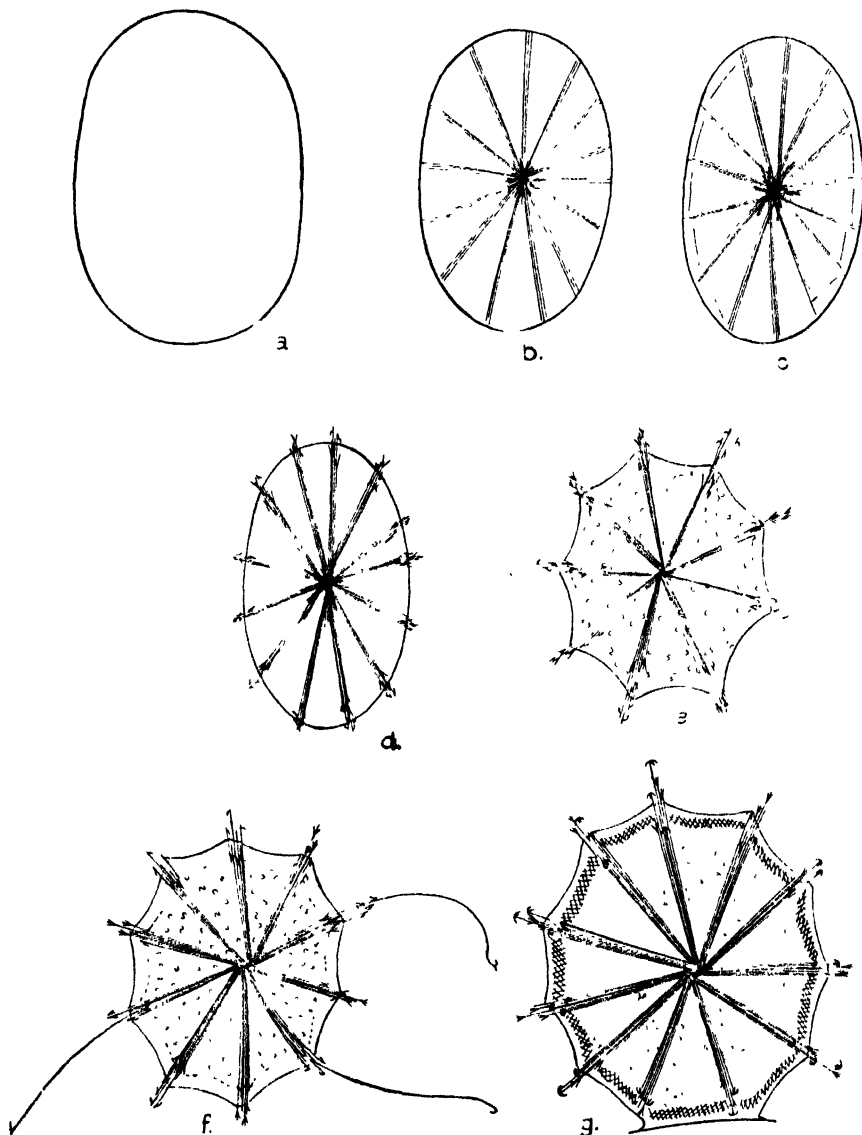
(iv.) *TETILLA CRANIUM* (Müller). (Text-figs. 4 & 5.)

Tetilla cranium is one of a group of species in which the embryo, when discharged from the maternal tissues, is complete in every part and is, in fact, a replica of the fully-grown form. To this extent therefore if there is any foundation in the suggestion that there are several post-larval growth phases we should expect to find something corresponding to them reflected in the

behaviour of the embryo which remains in the maternal tissues until a late stage in development has been reached.

The embryo of *T. cranium* is at first aspiculous and subspherical, and in this

Text-figure 4.



Stages in the development of *Tetilla cranium* (Müller).

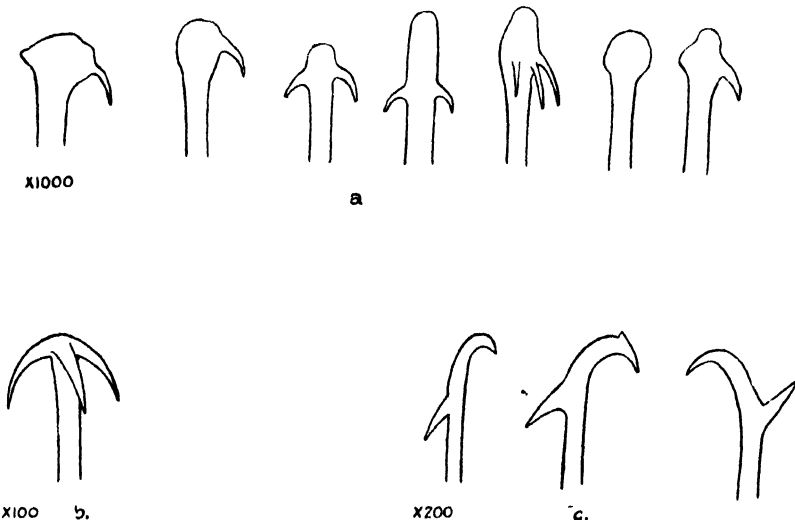
From the aspiculous embryo to the smallest known post-larval stage. (Semi-diagrammatic.)

condition appears as a mass of polygonal cells of different sizes (text-fig. 4, a). Differentiation then sets in, and an outer layer of columnar cells and an inner

mass of irregular cells can be distinguished. At this stage a cap of ciliated cells, continuous with the rest of the outer layer, appears at each end of the embryo, and since cilia have not been observed at later stages this may be taken to correspond to the larval stage of other species. Then the embryo becomes elliptical and decreases slightly in size, and radially arranged oxea appear (text-fig. 4, *b*). Following this a few small oxea are developed, arranged tangentially to the surface (text-fig. 4, *c*), but these persist for a time only, and at the next stage, when trianes have been added to the radial bundles, they have disappeared (text-fig. 4, *d*). It cannot be ascertained whether it is the protrianes or the anatrianes that appear first; possibly they arise simultaneously.

Soon after the appearance of the trianes the tissues become differentiated into cortex and choanosome, the surface appears conulose, sigmata appear

Text-figure 5.



Anatrianes from *a*, an embryo of *Tetilla cranium* (Müller). $\times 1000$; *b*, a mature individual of the same species, $\times 100$; and *c*, from *Tethyopsilla metaclada* Lendenfeld, $\times 200$; for comparison with the embryonic spicules of *Tetilla cranium*.

(text-fig. 4, *e*), and, judging by the presence of long anchoring spicules projecting from the surface, it is at this stage that the young sponge is liberated (text-fig. 4, *f*).

The next stage known in the development of this species is that in which the young sponge has become fixed (text-fig. 4, *g*) and has a diameter of a few millimetres, but from this it can be seen that at least two changes have taken place since the young sponge left the maternal tissues. Not only are the heads of the trianes altered considerably in size and shape (text-fig. 5), but a stout palisade of oxea has appeared in the cortex.

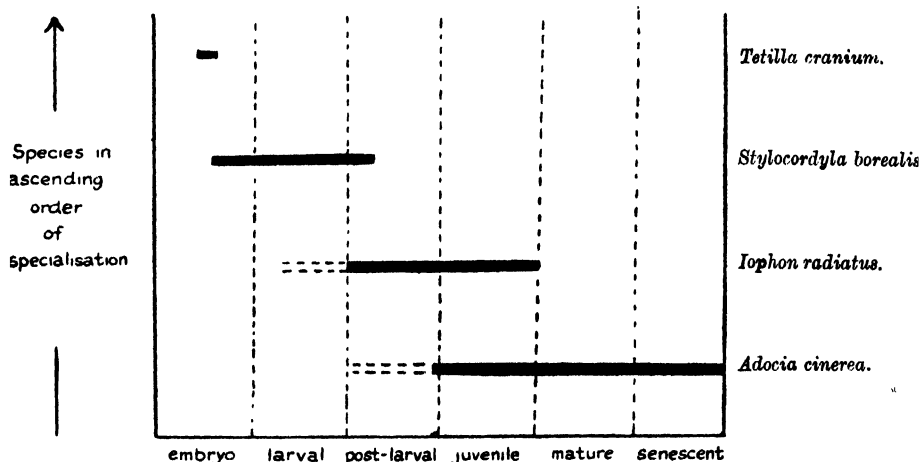
It is difficult to compare the various stages of the embryo of *T. cranium* with those of other species studied. Perhaps the larval may be said to begin with the appearance of the two caps of cilia, the post-larval stage with the appearance of the radial oxea, the juvenile stage with the appearance of the tangentially arranged oxea, the mature stage with the development of the

first triænes, and the senescent stage with the change in the triænes accompanied by the development of the cortical palisade. This cannot be settled, however, until more is known of the embryology of the rest of the Tetillidæ and other related families. There is one significant thing at least, that at what may be regarded as the juvenile stage a tangential dermal skeleton appears, although only as a transitory structure.

THE SIGNIFICANCE OF THE DERMAL SKELETON.

The appearance of a tangential dermal skeleton of small oxea in the embryo of *Tetilla cranium* is significant. In a former work (1929, p. 63) I have shown that a similar structure is present in the embryo of *Stylocordyla borealis*, but in that species it persists until the post-larval stage is reached. In *Hymedesmia areolata*, *Iophon radiatus*, and *Myxilla elongata*, three closely related species, a similar structure persists for some time after the fixation of the larva, but,

Text-figure 6.



even so, is shed at a comparatively early stage in life. Thus we have, in species representing three widely separated families, an homologous structure appearing, persisting for a varying length of time, and finally disappearing again before maturity. This in itself is striking, and it is natural to look for some evolutionary significance therein. In other species, as in *Adocia cinerea**, a similar dermal skeleton is present and persists throughout life; and, comparing this with the examples quoted above, it is seen that the longer the dermal skeleton persists the more primitive the species. Whether this can be accepted as a general rule in the Tetraxonida is as yet uncertain. A great deal more investigation will be needed to settle this, but the evidence afforded by the few species here dealt with is too remarkable to be ignored.

In *Tetilla cranium* we have a species which has reached a high degree of

* The genotype of *Gellius* (*G. jugosus* Bowerbank) has, contrary to the usual belief, a main skeleton practically identical with that of *Chalina*. *Adocia cinerea* Grant (= *Reniera cinerea* Auott.) has, in addition to a renieroid main skeleton, a tangential dermal reticulation of triangular and unispicular mesh.

specialization, and the tangential dermal skeleton appears for a brief period in the early life of the embryo. In *Stylocordyla borealis*, a less specialized species, it persists until the post-larval stage. In *Hymedesmia areolata*, *Iophon radiatus*, and *Myxilla elongata*, species showing but slight specialization, it appears at, and persists for a while after, the post-larval stage, and in *Adocia simulans*, a species of very simple structure and presumably primitive, it persists throughout life. This is expressed graphically in text-fig. 6 (p. 523) :—

There is yet another point in this connection which has an important bearing on the systematic study of the group—that the loss of the dermal skeleton, with the change in the character of the whole skeleton which often accompanies it, can only be effected by the extrusion of spicules to the exterior. In some specimens there are signs that this must have been taking place at the time they were caught. It has often been suggested that such a thing took place, but this appears to be the first time that positive evidence of it is forthcoming. This being so, it is now possible to interpret facts which have hitherto remained a mystery. In *Polymastia invaginata* Kirkpatrick the majority of specimens are covered externally with a dense pile of spicules (Pl. I. fig. 6). This varies from one individual to another, and occasionally a specimen is found in which the outer surface is bare of spicules (Pl. I. fig. 7). The explanation now offered is that the bare specimen was captured immediately after a wholesale extrusion of spicules, or moult. A similar series has also been observed in *Cinachyra barbata* Sollas (Pl. I. figs. 4 & 5), and it is probable that many supposed species are represented by specimens which recently moulted. Whether this process takes place continuously or at definite periods yet remains to be seen, but the recognition of its occurrence in whatever form is of extreme importance.

SUMMARY OF CONCLUSIONS.

1. In certain species of Tetraxonida the period of adult life may, in some cases, be subdivided into as many as three distinct growth stages, each characterized by some evident change in the form of the spicules, coupled with changes in the arrangement of the skeleton, or even with differences in the gross morphology.

2. A tangential skeleton is a primitive character, and species in which this persists throughout adult life may be regarded as having undergone little specialization.

3. Extrusion of spicules takes place either continuously or at definite periods in the life cycle. This has been assumed by previous authors, but without definite reason for so doing, and the proof now forthcoming enables us to explain the absence of particular categories of spicules from certain individuals of a species, the disorganization of the skeleton so often seen, and the differences in the arrangement of the dermal skeleton in different individuals of the same species.

4. In the identification of species not only must the normal fluctuating variations and those due to ecological, geographical, and environmental factors be considered, but also those due to age.

5. The order in which different forms of spicules appear in the life cycle indicates the order of their appearance in the evolution of the species, and probably, although this yet remains to be proved, when reduction of the skeleton takes place the last spicules to appear are the first to disappear.

I wish, in conclusion, to thank my colleague, Dr. E. I. White, for having read critically the MS. of this paper.

LIST OF WORKS REFERRED TO.

- BURTON, M. (1928.) A Comparative Study of the Characteristics of Shallow-water and Deep-sea Sponges, with Notes on their External Form and Reproduction. J. Quekett Microsc. Club, London, xvi. 95, pp. 49-70, 1 pl., 7 figs.
- BURTON, M. (1929.) Porifera. — Part II. Antarctic Sponges. British Antarctic ('Terra Nova') Expedition, 1910, Natural History Report, Zool. vi. no. 4. London, 4to, pp. 393-458, 5 pls., 9 figs.
- HENTSCHEL, E. (1914.) Monaxone Kieselschwämme und Hornschwämme der deutschen Sud-polar-Expedition, 1901-1903. Deutsch. Sudpol-Exped. xv. Zoologie, 7, pp. 32-141.
- KIRKPATRICK, R. (1908.) Tetraxonida. National Antarctic Exped. Natural History. iv. 2, 56 pp.
- TOPSENT, É. (1901.) Spongiaires. Résult. Belgica Zool. Anvers, 4to, 54 pp.
- TOPSENT, É. (1908.) Spongiaires. Expedition antarctique française (1903-5) (Expédition Charcot). Paris, 4to, 37 pp.

EXPLANATION OF THE PLATE.

- Fig. 1. Juvenile form of *Hymedesmia areolata* Thiele. $\times \frac{1}{2}$.
2. Juvenile form of *Myxilla elongata* Topsent. $\times \frac{1}{2}$.
3. Mature form of *Myxilla elongata* Topsent. $\times \frac{1}{2}$.
4. Specimen of *Polymastia megalinata* Kirkpatrick, with dense surface pile of spicules. $\times \frac{2}{3}$.
5. Specimen of *Polymastia unguinata* Kirkpatrick, with surface bare. $\times \frac{2}{3}$.
6. Specimen of *Cinachya barbata* Sollas, with dense surface pile of spicules. $\times \frac{1}{2}$.
7. Specimen of *Cinachya barbata* Sollas, with surface bare. $\times \frac{1}{2}$.

28. Report on the Deaths occurring in the Society's Gardens during the Year 1930. By Brevet-Col. A. E. HAMERTON, C.M.G., D.S.O., late R.A.M.C., Pathologist to the Society.

[Received April 14, 1931 · Read April 14, 1931.]

The total number of cases examined in the Prosectorium during the year was 1211, or 90 less than in 1929.

Of the total deaths 38 per cent., comprising 93 Mammals, 186 Birds, and 192 Reptiles and Amphibia, died within six months of arrival, *i. e.*, during the period of acclimatization. The incidence of such deaths, which occur mostly among small and delicate creatures from the Tropics, is less than it was for last year, and there has been a general fall in the death-rate affecting Mammals and Birds.

The number of deaths among Mammals and Birds respectively, and the ratios of deaths per average strength for the year, are tabulated thus :—

TABLE I.

| 1930. | Average strength. | Deaths. | Ratio of deaths per average strength. |
|-------------------|-------------------|---------|---------------------------------------|
| MAMMALS | 822 | 265 | 32·2 per cent. |
| BIRDS | 1937 | 594 | 30·6 „ „ |
| Total | 2759 | 859 | 31·1 „ „ |

The death-rates for Mammals and Birds show a decline of 0·74 per cent. and 0·39 per cent. respectively on the estimated figures for 1929.

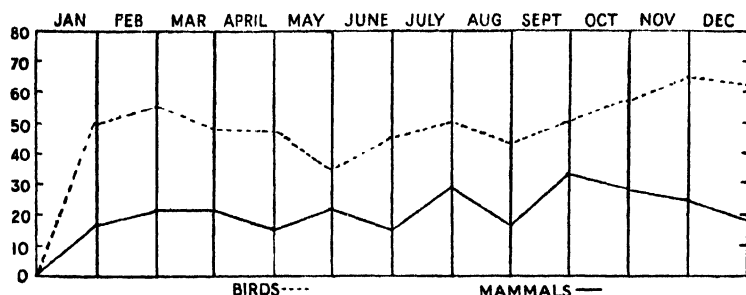
Reptiles and Amphibia.

Since it is not possible to examine post-mortem all the small reptiles and amphibia (usually purchased as collections comprising 150 or more specimens) that die from the effects of the voyage shortly after landing in England, it has been decided to figure separately the deaths in these classes, and to exclude those that occur within the quarantine period of 28 days after arrival.

The average strength of Reptiles and Amphibia recorded for the year is 2836.

The total deaths recorded are 1143, of which 352 were investigated and 791 were not investigated, owing to loss, destruction, or decomposition of the bodies.

The monthly fluctuations in the death-rate from all causes among Mammals and Birds may be represented by graph thus :—



The commonest causes of death among all classes were :—

1. Diseases of the Respiratory System 177 or 14·6 per cent.
2. Diseases of the Digestive System..... 166 or 13·7 per cent.
3. Injuries and Accidents..... 230 or 18·9 per cent.

The mortality from diseases of the respiratory system is less than that of last year. Inflammatory conditions of the air-passages and lungs, exclusive of tuberculous and mycotic infections, are most destructive among small tropical species during the winter months, and the mortality from diseases in this category shows much the same seasonal fluctuations as obtain in the human population living in northern cities.

Diseases of the digestive system are second in order of destructiveness. Probably diseases in this category are not to the same extent due to climatic conditions, and therefore may be more readily checked and controlled by sanitary precautions.

Accidents and Injuries have caused an increased mortality among small birds and mammals. They are mainly due to the combative and predatory instincts of the creatures themselves ; but a serious proportion of such deaths are due to the depredations of rats and mice, which, despite an intensive campaign against them, were unusually prevalent during the last quarter of the year.

The number of deaths from injuries among reptiles is insignificant.

The general health and condition of the larger species has been very good, and several pairs of mammals, notably Lions, Wolves, African and American Buffalo, Pigmy Hippopotamus, Anoa, Mountjac, and Puda Deer, have bred and produced healthy and vigorous young, and it is hoped to improve the fecundity and vigour of breeding stock by providing them, so far as is possible, with appropriate diets containing those accessory constituents which modern research has shown are essential for healthy growth, the maintenance of fertility, and the upkeep of resistance against disease.

A brief account of the most common diseases will now be given.

I. *Diseases of the Respiratory System.*

The deaths from diseases of the respiratory system are specified thus :—

| | Mammals. | Birds. | Reptiles. |
|--|----------|--------|-----------|
| Congestion and Œdema of Lungs | 3 | 33 | 15 |
| Pneumonia | 10 | 34 | 43 |
| Bronchitis and Broncho-pneumonia | 24 | 7 | 7 |

Animals that can be accommodated in the open air throughout the year suffer in a less degree from acute inflammations of the lungs than those creatures which, because of their inability to withstand low temperatures, must needs be kept indoors in artificially heated, dusty, and sometimes overcrowded quarters. The open-air Parrot Aviary, where hardy species of Macaws, Cockatoos, and other Psittaciformes live all the year round, is the healthiest aviary in the Gardens.

It is hoped that the methods adopted for increasing the humidity and reducing the dust in the heated air of the tropical houses, and measures taken for the spacing out of delicate tropical species, will result in a reduction of the incidence of respiratory diseases among them.

Among recently imported Snakes and Lizards inflammations of the lungs are most destructive; the affected lung or lungs are commonly deep red in colour, airless, and semi-solid; the central lumina may be filled with a blood-stained coagulum like red-currant jelly and the alveoli infiltrated with a similar exudate containing inflammatory cells or cheesy pus, according to the duration and severity of the disease. Micro-organisms in great variety are invariably present.

A typical case of "Strangles" occurred in a Mongolian Wild Horse (*Equus caballus przewalskii*), and is included in this category. There was found post-mortem severe congestion and oedema of the respiratory mucosa affecting the glottis and upper part of the trachea, also patches of grey slough in the pharynx, and a gelatinous exudate in the aryteno-epiglottic ligaments. The lungs were congested and oedematous. The whole chain of cervical glands were acutely inflamed, many were purulent, and the submaxillary gland was converted into a bag of pus. Pus smears, appropriately stained, showed the characteristic long chains and loops of streptococci in great abundance. The disease was diagnosed clinically on the first appearance of symptoms, the animal was immediately isolated, and the usual sanitary precautions were taken. No other case occurred.

A remarkable case of mass infestation of the lungs with the cysticeric of one of the Taniidae (*Echinococcus*) occurred in a young Babirusa (*Babirusa babirusa*) that died a few weeks after arrival from Celebes. The weight of the animal was 24 lb., and the lungs weighed 2 lb. 5 oz. The connective tissue throughout the whole structure of the lungs was so closely infested with cysticerici that the organs bore a rough resemblance to bunches of grapes. The lung parenchyma between the cysts showed no pathological change except for Emphysema at the apices and some congestion and oedema of the bases. The pleurae were adherent, and the lobes of the lungs were stuck together by adhesive pleuritis. The intercostal spaces were obliterated. The pressure effects of the mass of cysts on the heart and great vessels must have been considerable, and it was strange that the respiratory function could have been so long maintained. The liver and spleen were also infested with numerous large cysticerici containing hooked scolices.

Sero-fibrinous pleurisy associated with bronchitis and areas of collapse around the base and anterior margins of the lungs caused the death of an adult Sacred Baboon (*Papio hamadryas*) that had lived for some years in the Monkey House. Both pleural cavities were distended with blood-stained effusion. The mucosa of trachea and bronchi was congested and oedematous, and their lumina contained much thick blood-stained mucous which plugged many of the smaller bronchioles. The lungs, except for the apices, which were emphysematous, were sodden with oedematous infiltration. No tuberculous deposits

were found, and examination of smears of the lung and pleural exudate for tubercle bacilli was negative, though a few gram plus cocci were found singly and in short chains.

Pneumonia.

In the pneumonia of small Mammals, Birds, and Reptiles, in which one or both lungs are found wholly consolidated and hepatized, I find the histological distinctions between lobar pneumonia and broncho-pneumonia, usually evident in human cases, are difficult to recognize. In cases therefore in which death is due primarily to pneumonic consolidation that is neither cancerous, tuberculous, nor mycotic, nor caused by other specific infection such as anthrax, the cause of deaths is recorded simply as "Pneumonia." Of the ten Mammals that succumbed to Pneumonia the largest was a Red Kangaroo (*Macropus rufus*). The term broncho-pneumonia is at present reserved for recording those cases that show a primary inflammation of the bronchial mucosa extending down and ending as a capillary bronchitis, with consequent localized or nodular areas of pulmonary consolidation separated by tracts of areated and serviceable lung.

Bronchitis and Broncho-Pneumonia.

During the winter months Apes share with human beings a special susceptibility to inflammations of the respiratory passages, which, as with us, usually commence with a "cold." They lack, however, the toleration and powers of recovery that we have acquired. With the Apes a cold is a serious disease which necessitates the patient's immediate removal to hospital, where, if signs of bronchitis or broncho-pneumonia supervene, they are carefully nursed day and night by their keepers and are treated medically exactly as a child with broncho-pneumonia.

Most of the young Anthropoids were down with "colds" or "flu" during the winter months, but we only lost one, a highly intelligent and docile Chimpanzee (*Pan satyrus*) that developed typical broncho-pneumonia. Two other cases of broncho-pneumonia, in a Gibbon and a Chimpanzee respectively, recovered.

Two Sacred Baboons (*Papio hamadryas*) also died from broncho-pneumonia after a residence of over five years on Monkey Hill.

Another valuable animal that succumbed to this fatal disease was the black variety of the Jaguar (*Felis onca*) (Satan) which had been eighteen years in the collection. Septic bronchitis, ending in destruction of the bronchial mucosa, bronchiectasis, broncho-pneumonia, and gangrene of the lung is a common ending to old specimens of the large Felidae.

A Raccoon and a Palm-Civet died from septic bronchitis and broncho-pneumonia secondary to septic stomatitis and necrosis of the teeth and alveolar processes.

II. *Diseases of the Digestive System.*

The causes of death included under this heading are specified thus :—

| | Mammals. | Birds. | Reptiles |
|---|----------|--------|----------|
| Catarrh of Intestines | 0 | 52 | 0 |
| Enteritis and Gastritis | 17 | 62 | 25 |
| Fæcal Impaction and Intestinal Obstruction .. | 2 | 5 | 7 |

Infectious Enteritis of Felidæ, commonly known as "Cat Distemper," is included under this heading.

Despite elaborate precautions for the prevention of this disease, an outbreak occurred among newly imported Felidæ during the months of July, August, and September, as in previous years; and on this occasion also the epizootic coincided with a "wave" in the incidence of the disease among domestic cats in the locality.

Two Leopard cubs, 6 Tiger Cats, 3 Leopard Cats, and a Marbled Cat (12 Felidæ in all) perished.

The clinical aspects, morbid anatomy, and histology of this disease as it occurs in wild Felidæ was described in my Report for last year. My remarks on this year's outbreak will refer to epizootological data and the hygienic aspect of the disease.

The first two cases occurred in two Leopard cubs that sickened of the disease in the Sanatorium on 22nd and 23rd July—a month after arrival from abroad. They were promptly moved to the new Isolation Ward (North Bank), where they died within forty-eight hours. The next case was in a Marbled Cat that arrived in the Sanatorium at about the same time (end of June) as the two Leopard cubs; it fell ill on 21st August and died within a week. No further cases occurred until September 18th, when a Rusty Tiger Cat that arrived on 2nd August was moved into the Small Cat House on 8th September after a period of five weeks' quarantine in the Sanatorium. The animal fell sick on September 18th and died within twenty-four hours. Its cage companion of the same species expired likewise two days after.

The disease having now started in the Small Cat House, spread to two Leopard Cats in adjoining cages. They both sickened on the 24th September, and were moved to the Isolation Ward, where they died the next day.

On September 26th two more Leopard Cats—one a recent (19/8/30) arrival from the Sanatorium, where it had been in quarantine since importation on 26th June—sickened of the disease: one died on 28th September, the other, its cage companion in the Small Cat House, where it had been a resident for over five years, had a mild attack of Cat Distemper and recovered naturally.

An American Tiger Cat imported on June 7th was moved into the Small Cat House on 8th September, and died of the disease on the 28th after twenty-four hours' illness. This cat had probably escaped infection in the Sanatorium, but contracted the disease in the Small Cat House.

Two Pampas Cats, both old inhabitants, that had been several years in the Small Cat House, fell sick on September 28th with what appeared to be a comparatively mild attack of Cat Distemper, and since both recovered it would seem that they, like the old Leopard Cat, had acquired a resistance to the disease which young and newly imported cats lack.

Three Tiger Cats imported in August or early September all died about two months after arrival. They were probably infected during their period of quarantine in the Sanatorium, where they had been in indirect contact with one of the Leopard Cats above noted.

Professor Edward Hindle, in conjunction with Dr. G. M. Findlay of the Wellcome Bureau of Scientific Research, have very kindly investigated material from these cases. They confirm the view that the microscopic organisms found in the lesions are, like those found in Dog Distemper and human influenza, secondary invaders which, as it were, "finish off" the patient, but the initial cause of the disease appears to be a submicroscopic agent.

Professor Hindle and his colleague are now carrying out research as to the properties of a virus or submicroscopic pathogenic influence that has been isolated from these cases. They have obtained important results which seem to indicate the true pathology of the disease and the possibility of instituting a method of treatment.

Notable points in the epizootology of this disease appear as follows :—

1. Epizootics of acute Enteritis in Cats, known as "Cat Distemper," appear to recur year after year among our newly imported small Felidæ during the months of June, July, August, and September. Only two cases have occurred during the winter months, though the disease is undoubtedly endemic among London domestic cats all the year round.

2. Small Felidæ appear to acquire some resistance to the disease by residence in the Gardens.

3. Large Felidæ, except when young and newly imported, are not readily infected. Lion cubs, however, are most resistant to infection, Leopard cubs are most susceptible.

4. The disease is endemic among domestic cats in London, which usually recover, but may be carriers.

5. It is impossible to prevent entrance of the virus into the Gardens.

6. The limit of the incubation period is not known; it may be a few days, or possibly extend to two months.

As regards measures for preventing the spread of infection : in addition to those already indicated (the most important of which is the immediate isolation of an infected animal and all direct "contacts," animate and inanimate) the history of this and former outbreaks of Cat Distemper seems to indicate that, in addition to a period of at least two months' quarantine in the Sanatorium, a further period of segregation is required for all newly imported cats of the highly susceptible species; and it is therefore suggested that a special den, with a run that could be partially turfed in summer and open for exhibition, should be set apart, preferably on the North Bank, for the reception and retention of newly imported small cats for a period of from six months to a year.

Psittacosis.

In the absence of the special facilities required for the isolation of the etiological factor in this disease, and for proving it by biological tests, I can only affirm that no disease which in its epizootological, pathological, or clinical aspects could be identified with psittacosis has been found in the Society's Aviaries, and it may be noted that the death-rate among Psittaciformes, especially from enteritis and respiratory diseases, has been much lower since the birds have been accommodated in the new Parrot House, where they have more air-space and the general sanitary conditions are much improved. For practical purposes of prevention Psittacosis must be viewed as a filth disease that is engendered by overcrowding in filthy accommodation during the collecting, transport, and marketing of the birds. The remedy is the application of sanitary measures in commercial and private collections.

The result of the intensive research by bacteriologists concerning the ætiology of this disease is that its bacterial origin has been disproved, and the

"virus" theory of its cause has been definitely established. The Zoological Society has supplied material, from parrots accidentally killed, for control experiments for research in the ætiology of psittacosis. Investigations have shown that the virus of psittacosis is undoubtedly of great interest and importance in veterinary and medical science, especially with regard to its possible relationship with the viruses of fowl plague and of certain affections of the human skin and nervous system with which it apparently has some affinities*.

Other morbid conditions of the alimentary system are recorded as follows :—

A Palm-Civet (*Paradoxurus hermaphroditus*) died from acute dilatation and rupture of the stomach, following a surfeit of bananas that had apparently burst the stomach in fermenting.

An African Civet-Cat (*Civettictis civetta*) died as a result of a remarkable series of abdominal catastrophes following chronic constipation. The cæcum and large intestines were enormously distended with tightly impacted scybala; the abdominal viscera were displaced and there was complete intestinal obstruction. The cardiac end of the stomach was herniated through the crura of the diaphragm. The duodenum was much distended and twisted upon itself near its junction with the jejunum, the ilium was invaginated into itself for a length of about 2½ inches, and there was much inflammatory reaction at the site of the duodenal volvulus and the iliac intussusception.

Duodenal ulcers with secondary bacterial infection of the bile-ducts and empyema of the gall-bladder caused the death of a Brown Capuchin Monkey (*Cebus fatuellus*).

A Harnessed Antelope (*Tragelaphus scriptus*) died from extensive non-tuberculous ulceration of the laminae of the omasum.

The rare Coquerel's Sifaka (*Propithecus coquereli*) lived only two months in the Gardens, when it succumbed to acute gangrenous inflammation of the cæcum, secondary to constipation and impaction of scybalous masses in the large bowel.

Among Birds non-tuberculous ulcerations of the alimentary canal are a fairly common cause of death. The following may be noted :—

A Cassowary (*Casuarus casuarus*) died from general septicæmia resulting from numerous small circular chronic ulcers of the cloaca for which no parasitic cause could be found. There was much gelatinous inflammatory exudate in the pelvic peritoneum and areolar tissue. The pericardium contained about 200 c.c. of blood-stained serous fluid, and there were small hæmorrhages under the epicardium and endocardium, especially around the bases of the valves of the heart.

An Undulated Hornbill (*Rhyticeros undulatus*) that had been eleven years in the collection died from general peritonitis due to perforation of a small circular ulcer of the ilium and extravasation of intestinal contents. The bird appeared to be very old; extensive fibrotic and fatty degeneration was found in most of the viscera and in the arterial system.

A Dominican Gull (*Larus dominicanus*) died from a duodenal ulcer situated at the entrance of the pancreatic ducts. There was secondary septic inflammation of both lobes of the pancreas.

Two Ibises (*Endocimus rubra* and *Ibis æthiopica*) died from ulcers of the gizzard for which no cause was apparent.

Intestinal obstruction, caused by impaction of chalk-like masses of urates

* Gordon, M. H., "Virus Studies concerning the Ætiology of Psittacosis," 'Lancet,' May 1930.

etc. in the cloaca, is a condition to which birds in captivity are liable. The following example is typical :—

A South African Ostrich (*Struthio australis*), an old bird that had been five years in the Gardens, died primarily from intestinal obstruction due to the impaction of a large chalk-like mass of urates in the cloaca. The intestinal obstruction had apparently given rise to reversed peristalsis in the oviduct, rupture of an ovum, and escape of egg-material into the peritoneal cavity. The kidneys were affected with fibro-fatty degeneration. The ureters and their radicles were greatly distended with semi-solid urates.

Among Reptiles and Amphibia diseases of the digestive tract cause heavy loss. The following cases are representative :—

Extensive ulceration of the gastric mucosa, in which nearly the whole of the inner coat of the stomach was destroyed, caused the deaths of a Bengal Monitor (*Varanus varanus*), a Numskull Frog (*Rana adspersa*), and a large Tortoise (*Testudo denticulata*).

A very large Hamadryad (*Naja hannah*), 14 feet long, which was said to have fasted for nearly a year, died after swallowing a monitor. An abscess, 3 inches in diameter, probably an infected helminth cyst, of which there were several in the peritoneum, was found in the muscular wall of the stomach, and there was also a severe membranous enteritis.

A Common Boa (*Boa constrictor*) was killed by order on account of œdema and necrosis of the skin, which was so soft and sodden that it could be peeled off the body like wet paper. A large ulcer with raised indurated edges and covered with a leathery slough was found in the gastric mucosa. The skin condition seems to be a disease peculiar to snakes ; it is rather uncommon and not always associated with grave internal disease. The cause is not known.

General septicæmia, with pyæmic abscesses in liver and lungs and effusions into serous membranes, are very common complications of the severe and ulcerated forms of enteritis and gastritis in Reptiles:

Injuries and Accidents.

Among the deaths from accidental injuries the following may be cited :—

A pregnant Lechwe Waterbuck (*Kobus leche*) was injured in the flank by a companion. There was a small lacerated wound in the right posterior quadrant of the abdomen. Gas gangrene had commenced in it and was spreading along the abdominal muscles and fascial planes, and there was a general infection with gas forming anærobic bacilli (*B. welchii*). There were contusions and hæmorrhages on the right cornua of the uterus, which contained a full-time foetus in normal presentation. The amnion was ruptured, the liquor amnii had escaped. The foetus was dead and "gassy," and was infected with gas-forming microbes.

A young Beaver (*Castor canadensis*) that was born in the Menagerie and was successfully reared in the Sanatorium was killed by its parents when returned to the Beaver Pond.

A Canadian Porcupine (*Erethizon dorsatum*) was killed by order, on account of paralysis of the hind limbs. Post-mortem revealed an old fracture dislocation of the spine, with distortion and compression of the spinal cord.

A Binturong (*Arctitis binturong*) died as a result of perforation of the rectum by a porcupine quill.

Among birds a valuable Emu (*Dromiceius n. hollandiæ*) died from per-

foration of the intestine with a piece of wire which passed into the liver, where it gave rise to a large abscess.

A King Vulture (*Gypagus papa*), a Scops Owl (*Otus scops*), and a Reeves' Pheasant (*Syrmaticus reevesi*) died as a result of similar dietetic indiscretions.

Tuberculosis.

The number and percentage of deaths that occurred annually from this disease among Mammals, Aves, and Reptilia respectively, and the annual totals for the three classes of animals for five consecutive years are shown in the table below :—

TABLE II.

| Year. | Mammals. | Aves. | Reptilia. | Totals. |
|-------|--------------|-------------|-----------|------------------------------------|
| 1925 | 24 or 6.7 % | 21 or 4.0 % | 3 | 48 or 3.9 per cent. of all deaths. |
| 1926 | 38 or 12.5 % | 13 or 2.4 % | 3 | 54 or 4.7 " " |
| 1927 | 13 or 4.3 % | 12 or 2.5 % | 3 | 28 or 2.7 " " |
| 1928 | 22 or 7.6 % | 39 or 6.1 % | 1 | 62 or 5.1 " " |
| 1929 | 12 or 4.0 % | 29 or 4.6 % | 3 | 44 or 3.3 " " |
| 1930 | 12 or 4.3 % | 26 or 4.3 % | 4 | 42 or 3.4 " " |

In most cases the disease is caught in the Gardens, but there are numerous instances where it has been introduced by mammals or birds obtained from other collections that have died of advanced chronic tuberculosis shortly after arrival in London.

In the application of the tuberculin test to newly arrived wild animals, such as Cervidæ and Bovidæ, there is often serious risk of injury to the beast or the attendant in catching it up. So this method of detecting the disease in mammals is not practicable as a routine measure.

The recognition of the disease in Birds is rarely possible during life, since even when extensively infected they may be in excellent plumage and show no indication of wasting until shortly before death. It does not appear to be at present possible to eradicate the germs of this disease from ground where they have been sown and reaped continuously for probably over a century, and are nurtured in animals in which it is rarely practicable to diagnose the infection in an early stage, or to segregate those that are infected. Moreover, our ample stock of tubercle bacilli is augmented by frequent importations from abroad, and even by our London wild fowl and game-birds from home estates. I believe, however, experience shows that the ravages of this disease in our Collection can be and are restricted by the application of sanitary measures that are practicable—such as the immediate destruction of infected animals whenever the disease can be diagnosed during life ; by improvements in the housing and general hygienic conditions of the creatures under our care ; by the careful observation of newly imported susceptible animals whilst they are in quarantine and the elimination of those that are found to be infected.

Under the more natural conditions and greater freedom that animals will enjoy at Whipsnade it is not expected that tuberculosis will be the serious problem it is in the crowded London Gardens. In stocking the place, however, some discrimination will be advisable before admitting susceptible mammals and birds that have been previously living for a long period under conditions of captivity or semi-domestication.

The mammalian cases of tuberculosis were distributed among the following families :—

| | |
|-----------------------------------|----|
| Cercopithecidae (Langur) | 1 |
| Cebidae (New-World Monkeys) | 1 |
| Bovidae (Antelope)..... | 4 |
| Cervidae (Deer) | 2 |
| Felidae (Tiger)..... | 1 |
| Ursidae (Bear) | 2 |
| Pteropodidae (Fruit-Bat) | 1 |
| | — |
| Total | 12 |
| | — |

In twenty-three necropsies on Primates only two cases of tuberculosis were found, namely, in a Langur from India and in a Brown Capuchin (*Cebus fatuellus*) from South America. Both these animals arrived in a tuberculous condition, and died in quarantine a few days after arrival.

Of the mammalian cases the following are noteworthy :—

A newly arrived Robinson's Langur (*Pithecus robinsoni*) was suspected of tuberculosis. Its faeces were examined microscopically, and endothelial cells filled with nests of acid-fast bacilli were numerous in the preparations. Tuberculosis was diagnosed, and the animal killed as a sanitary precaution. Extensive tuberculous ulceration of the ileum was found affecting the mucosa, solitary follicles, and Peyer's patches.

Although the finding of a few acid-fast bacilli in the excreta of an herbivorous animal is of no significance, I have found on more than one occasion that when endothelial cells containing nests of acid-fast bacilli within them are excreted in considerable numbers intestinal tuberculosis can be diagnosed. Examination of faeces for tubercle bacilli is a routine procedure in newly arrived Primates in which the general condition is suggestive of tubercular infection.

A Blackbuck (*Antelope cervicapra*) died from pulmonary tuberculosis of the bovine type five months after arrival in the Gardens. The disease was chronic, and advanced to such an extent that it was almost certainly infected elsewhere. One of its companions also died of chronic tuberculosis within three weeks of arrival; the disease was then immediately diagnosed by the presence of a breaking down tubercle under the jaw.

The animals were members of a small herd of Blackbuck that was imported from India in April, and there can be little doubt they were infected in that country.

Another Blackbuck of this herd had been sent to Whipnade, and died of advanced tuberculosis shortly after arrival there.

These three cases are of hygienic interest in that they were retained in the London Gardens for a long period of segregation pending despatch to Whipnade; they demonstrate the necessity for an adequate period of quarantine for all newly imported Bovidae before they are turned out.

Moreover, recent records of similar importations of communicable disease in other animals and birds clearly indicate the prudence of augmenting our facilities for segregating and testing such new arrivals as may introduce infectious or contagious maladies.

A Sable Antelope (*Hippotragus niger*) that had been nearly seven years in the Collection suffered from an intractable skin disease (? Seborrhoea) and died in the Sanatorium from the chronic bovine form of tuberculosis. Both lungs and pleura were studded throughout with tubercles. The spleen

and liver also contained many tuberculous nodules. The hepatic gland was the size of a hen's egg and was full of pus. There was a tuberculous deposit about the size of a bean in the left kidney. The bronchial and tracheal lymph-glands were enlarged and caseating.

Tuberculosis in large Felidæ is fortunately not very common. The case of a large Tiger (*Felis tigris*) is therefore worth recording. The animal had been ill for some months with "chest trouble" and progressive emaciation. The condition found at post-mortem was purulent broncho-pneumonia with extensive cavitation and gangrene of both lungs. The pleuræ were thickened and inflamed and contained about 500 c.c. of straw-coloured fluid. The bronchi were filled with foul muco-pus. The lower lobes of both lungs were mostly converted into abscess cavities, which were blown out with air and contained dirty-looking greenish pus and shreds of gangrenous lung-tissue. The walls of the cavities consisted of ragged broken-down pulmonary tissue surrounded by consolidated margins of the lung. The upper two lobes of the right lung were dirty grey in colour and completely consolidated. The upper lobes of the left lung were emphysematous and contained deposits of broken-down caseating tissue. Smears from the consolidated portions of the lung contained acid-fast bacilli in considerable numbers, though in sections they were scanty and not easily found. This was a case of feline phthisis, with secondary infections of the cavities with pyogenic and putrefactive organisms. Mr. Lovell, late bacteriologist to the Society, has kindly examined portions of the lung and bronchial glands. He agrees that the primary infection was tuberculous, and from the gland he has isolated a tubercle bacillus which by cultural and pathogenicity test appears to be bovine type. If this distinctive disease of the large Felidæ is primarily a tuberculous infection, its apparently infective nature can be understood. The disease is chronic, and inevitably progresses to a fatal termination.

A case of tuberculosis occurred in a Sun Bear (*Ursus malayanus*) that had been six years in the Gardens. It is of interest in that the meninges were affected. The primary lesion was a tuberculous broncho-pneumonia with pleural effusion. Small purulent tuberculous foci and areas of consolidation were found in the lungs. The tracheo-bronchial glands were enlarged; some of them contained tuberculous abscesses, and there was pus in the bronchioles, bronchi, and trachea. The meninges at the base of the brain were thickened and adherent, bathed in pus, and studded with small tubercles, and there was a tuberculous abscess in the right internal capsule of the brain. Tubercle bacilli were found in smears of pus from all lesions.

Another Sun Bear (*Ursus malayanus*) was infected with tuberculosis on arrival, and died shortly afterwards in an advanced and generalized condition of the disease. Both lungs were packed with tubercles and almost entirely consolidated, and there was a typical phthisical cavity at the base of one lung. The thyroid, thymus, and tracheal glands were all matted together in a confused mass of tubercles. There were tabes mesenterica, tuberculous peritonitis, and tubercular deposits in the kidneys and adrenals. The animal had been transferred to London in a tuberculous condition from another collection. *Bacillus tuberculosis* of bovine type was cultured from this case.

An Indian Fruit-Bat (*Pteropus giganteus*) that had been eight years in the Gardens died from tuberculous peritonitis and tabes mesenterica. Miliary tubercles were scattered over the peritoneal surfaces of the liver and spleen, and about 100 c.c. of slightly blood-stained fluid was found in the peritoneal cavity. The mesenteric and hepatic lymph-glands were enlarged to such an extent as to cause pressure on the mesenteric veins and hyperæmia of the

intestinal walls and mucosa. Many of the enlarged glands were caseating and contained tubercle bacilli in large numbers. The tuberculous lesions in this case were confined to the abdominal lymphatic system, and none could be found elsewhere.

Dr. Stanley Griffith, of Cambridge, has kindly investigated tuberculous material from this animal, and proved it to be infected with the bovine type of *Bacillus tuberculosis*.

The bat had been eight years in the Collection, and the only milk it ever had was an occasional allowance of condensed milk. A similar finding of bovine tubercle in an Indian Fruit-Bat is recorded by Dr. Scott in his Annual Report for 1925.

The twenty-six cases of tuberculosis among Birds were distributed among the following orders :—

| | |
|----------------------|----|
| Accipitriformes..... | 1 |
| Anseriformes..... | 9 |
| Ardeiformes | 1 |
| Galliformes | 7 |
| Columbiformes | 1 |
| Passeriformes | 3 |
| Piciformes | 1 |
| Psittaciformes | 3 |
| | — |
| | 26 |

All the cases among Anseriformes came from the Three-Island Pond. The prevalence of tuberculosis among the ducks on this pond is of interest in that it is not confined to pinioned birds, but occurs also among non-pinioned Mandarin Teal that have access to other ornamental waters in the vicinity. It is curious that the disease has not been found among the Flamingoes occupying the same enclosure.

Among the Galliformes were three Pea-fowl and four Common Pheasants (*Phasianus colchicus*). The latter were the last of a batch of seven that came from an estate in Westmorland, all of which died from generalized tuberculosis shortly after arrival and were probably infected when received.

Among noteworthy examples of this disease in birds the following may be mentioned :—

A Jackson's Whydah-bird (*Drepanoplectes jacksoni*) that had lived in the Gardens for twenty-one years died from the pressure effects of an abdominal tumour which was about the size of a filbert-nut and occupied most of the abdominal cavity, displacing the viscera. On section the tumour was found to consist of cheese-like material enclosed in a fibrous capsule. Microscopical examinations revealed masses of tubercle bacilli in a structureless matrix with giant-cell systems in the enveloping capsule. The spleen could not be found, and it seemed that the tumour was an encysted and quiescent tuberculous deposit which had originated in the spleen and had completely destroyed any sign of splenic tissue. No active tubercular disease could be found in any part of the body, and the only other pathological condition found was extensive fatty atheroma of the aorta, the first part of which was dilated to form an aneurismal sac nearly as big as the heart. Despite the bird's age and loss of spleen its general condition was good, it was in full breeding-plumage, and the testicles showed normal seasonal activity.

Another curious case of tuberculosis occurred in a Green-billed Toucan

(*Rhamphastos dicolorus*) that had been seven years in the Collection. The bird was killed by order on account of difficulty of breathing, apparently due to obstruction in the respiratory passages. At the post-mortem examination it was found that the whole trachea from larynx to syrinx was lined and partially obstructed with a whitish caseating deposit on the mucous membrane. Microscopical examination revealed masses of tubercle bacilli in the tracheal mucosa, which was extensively ulcerated and destroyed. The lungs were congested and oedematous, but contained no tuberculous deposits, and there was no sign of tuberculosis elsewhere.

A Mandarin Duck (*Aix galericulata*) that had been ten years in the Gardens presented a remarkable degree of tuberculosis of the kidneys. The lower pole of each kidney was swollen to form an irregular nodular tumour the size of a large walnut. On section the swelling was found to consist of a mass of tuberculous nodules containing swarms of tubercle bacilli. The adrenals were normal. The primary focus appeared to be in the lungs.

A Yellow-winged Parrakeet (*Brotozeris virescens*) died from a big tumour of the adrenal glands, which were uniformly enlarged and conjoined. On microscopical examination the tumour was seen to be a mass of tuberculous deposits packed with acid-fast bacilli. The centre of the tumour was necrosed and surrounded by a giant cell system. There were no other deposits.

Reptilian tuberculosis occurred as follows :—

In a Long-necked Terrapin (*Chelodina longicollis*) tubercles about the size of a hemp-seed were scattered throughout both lungs. There was no pulmonary consolidation, but the large air-spaces were filled with blood-stained gelatinous exudate. The hepatic lymph-gland was much enlarged and consisted of a cluster of tuberculous nodules containing enormous numbers of acid-fast bacilli. Dr. Stanley Griffith and Mr. Lovell, of the London School of Tropical Medicine, have cultured the organism, which is known as the cold-blooded or reptilian type of tubercle bacillus, and is pathogenic to frogs. The relationship of this microbe to the bacillus of human, bovine, and avian tuberculosis is doubtful.

In a Black-and-Gold Tree-Snake (*Boiga dendrophila*) the upper part of the lung contained a few small tubercles and in the lower half a tubercular abscess. Acid-fast bacilli were numerous in the lesions, and this specimen also was sent to Dr. Stanley Griffith.

In a Mocassin Snake (*Ancistrodon piscivorus*) the infection was general. Caseating tuberculous deposits were found in lung, liver, spleen, kidneys, and mesentery. Masses of acid-fast bacilli were found in smears from all the lesions.

I will conclude my remarks on tuberculosis by referring to the apparent rarity of tuberculous osteitis and arthritis in animals. I have not yet seen a case of primary tuberculous infection of joint or bone in captive wild animals, and only two, both in Primates, are recorded by my predecessor Dr. H. H. Scott; whereas in human pathology tuberculous lesions of joints and bones account for half the cripples in our hospitals for children.

Mycosis.

Apart from the fact that few susceptible birds like Penguins have been imported during the year, there has been a very satisfactory fall in the incidence of this disease. Only nine (1.5 per cent.) of birds and four (1.16 per cent.) of reptiles succumbed to mycosis, whereas in 1929 there were fifty (9.76 per cent.) of avian deaths from this disease. There are no deaths from mycosis in mammals to record this year.

The following avian cases may be noted :—

Two cases occurred in Penguins. One bird, a King Penguin (*Aptenodytes patagonia*), had been in the Gardens for three years and six months. It was very fat, but had a difficult moult and was entirely naked during most of the summer. The anterior intermediate air-sacs were lined with a tough, shrunken, and apparently dead felting of mycotic growth, in which neither fruit-heads nor other evidence of activity could be recognized. On the surface of the left lung, however, there were small recently formed mycotic foci, surrounded by extensive areas of congestion and consolidation implicating almost the whole lung; apparently an acute infection of the lung had arisen from chronic or quiescent foci of the disease in the air-sacs.

The other case, a Rock-hopper Penguin (*Catarrhactes chrysocome*), was one of two survivors of a batch of sixteen Penguins that arrived eighteen months ago from the Falkland Islands. The disease was extensive and of long standing. The air-sacs were distended with thick hard lumps of mycotic deposit which encroached on the thoracic and abdominal cavities and displaced the viscera. In this case also death was due to pneumonic consolidation as a result of invasion of the lung by miliary mycosis.

An Argus Pheasant (*Argusianus argus*) died from suffocation caused by a mycotic growth (*Aspergillus*) in the syrinx, which completely blocked the lumen of the right bronchus. There was also a mycotic nodule in the substance of the right lung, which was severely congested and in part consolidated.

A Sugar-bird (*Cyanerpes cyaneus*) died from pulmonary mycosis affecting the left anterior intermediate air-sac, with extensive invasion of the lung with mycotic elements and consequent pneumonic consolidation.

Two Bull-Frogs presented the macroscopical and microscopical lesions of generalized infection with the fungus described as *Monilia batrachia* by Dr. Scott.

Diseases of the Blood and Circulatory System.

Anæmia accounted for the deaths of one Mammal, nine Birds, and one Reptile. Seven of the birds, six of which were Ornate Lorikeets (*Trichoglossus ornatus*), died shortly after importation from severe anæmia associated with mass infection of the blood with the parasites of bird malaria (*Hæmoproteus*). In all cases the blood infection was intense, and about half the blood corpuscles contained parasites which were seen in all stages of growth, including many free gametes. On looking at a cage of these birds one morning I saw one suddenly drop dead from its perch. I examined it at once, and found most of the blood-cells were infected with hæmoproteus. Sections of the brain and internal viscera were made, but showed nothing in any way resembling human cerebral malaria. There was, however, an intense concentration of parasitized cells and pigment in the lungs, which were congested. It would appear that death was due to asphyxia from clogging of the lungs with parasites and pigment.

Grave degrees of primary anæmia, characterized by extreme pallor of the muscular system, lungs, liver, and kidneys, and a thin watery condition of the blood, with mononuclear leucocytosis and irregularity in shape and size of the red blood-corpuscles, some of which contain no nuclei, caused the death of a Glossy Ibis (*Plegadis falcinellus*) and a Scarlet Ibis (*Eudocimus rubra*). In a Rosy-faced Love-bird (*Agapornis roseicollis*) anæmia was associated with pronounced jaundice.

In two birds anæmia was associated with old age and several years residence in the Gardens. In both cases the microscopical blood-picture was

that of pernicious anæmia, in which the normoblasts were represented by red cells having double or quadruple nuclei associated with other erythrocyte abnormalities usually found in extreme anæmia of pernicious type.

In a Sun-bird (*Nectarinia*) the blood-picture was that of spleno-medullary type, and was associated with an enormous spleen, which filled up half the body-cavity to the displacement of other organs.

In a newly arrived African Civet (*Civettictes civetta*) that was killed by order as unfit for exhibition, piroplasmiasis was found. The parasites were found in pairs in the red blood-cells, also free in the plasma. The specimen was referred to Dr. Wenyon, F.R.S., of the Wellcome Bureau of Scientific Research, who identified the parasite as probably *Babesia civettæ*, described in 1920 by the Leger Brothers from the blood of an African Civet. The blood was thin and watery, and there was general anæmia of the tissues.

An Iguana (*Iguana iguana*) died from a severe leukæmia in which the white cells in the blood appeared to outnumber the red corpuscles. The blood was a pale pink in colour. No abnormality was recognized in the internal organs.

Diseases of the Heart and Blood-vessels accounted for the deaths of 1 Mammal, 8 Birds, and 2 Reptiles.

A Black Lemur (*Lemur macaco*) died from a hæmorrhagic infarction of the heart-muscle, which occupied nearly the whole of the apical portion of the left ventricle. The infarct was associated with atheroma of the arteries and extreme obesity.

The following cases of Endocarditis in birds may be noted :—

A Peacock Pheasant (*Polyplectron bicalcaratum*) died from chronic endocarditis, with an acute exacerbation and deposits of recent vegetations on the mitral valve, which were sclerosed and œdematous. On removing the calvarium a subdural hæmorrhage was found enclosing the whole brain in blood-clot. There was no sign of injury.

A Bar-tailed Godwit (*Limosa lapponica*) died from endocarditis affecting the mitral valve, which was encrusted with verrucose vegetations.

A Vulturine Guinea-fowl (*Acryllium vulturinum*) died as a result of verrucose endocarditis affecting the muscular plate representing the tricuspid valve. The vegetations almost occluded the auriculo-ventricular opening. There was evidence of considerable myocardial inflammation.

A Black-backed Gull (*Larus marinus*) died from chronic endocarditis, apparently of old standing. There was much sclerosis and puckering of the flaps of the mitral valve, the chordæ tendineæ were thickened and contracted, and there was a line of small vegetations along the septæ and lateral walls of the right auriculo-ventricular opening. All the great arteries were atheromatous and their lumina very constricted in places. The great veins were dilated and full of clot, the liver was atrophied, and the lungs were in a condition of pneumonic consolidation.

A Golden Hangnest (*Icterus xanthorus*) that had been fifteen years in the Gardens died as a result of fibrosis of the auricles and advanced atheroma.

A Ruff (*Pavoncella pugnax*) that had been two years in the Gardens and was excessively fat died from heart failure due to fatty infiltration and degeneration of the myocardium. A Roller (*Coracias garrulus*) died from a similar condition; the whole heart of this bird was encased in fat.

Pericarditis with purulent effusion caused the death of a Rhesus Monkey (*Macaca mulata*). *Bacillus pyocyaneus* was isolated in pure culture from the pericardial pus. The source of infection could not be found. Examination for tubercle was negative.

An Eagle-Owl (*Bubo maximus*) succumbed to pericarditis with effusion associated with chronic nephritis.

A Say's Toad (*Bufo cognatus*) died from myocarditis and hæmorrhagic pericarditis, possibly caused by numerous helminth cysts located in the areolar tissue around the base of the heart.

A Nose-horned Viper (*Bitis nasicornis*) died from purulent pericarditis and myocarditis.

Diseases of the Urinary System.

Diseases of the kidney caused the deaths of 11 Mammals, 27 Birds, and 2 Reptiles.

The following mammalian cases may be noted :—

A Ring-tailed Coati (*Nasua nasua*) that had been nine years in the Collection died from impaction of renal calculus in the right ureter. Numerous calculi were found in the pelvices or embedded in the calices of both kidneys, which showed also fibrosis and contraction of the organs, with atrophy of the glandular substance and cystic dilatation of the pelvis and urinary tubules. A calculus about the size of a hemp-seed was tightly impacted in the right ureter. The stones were all of a dirty grey or brown colour, angular in shape, dense, hard, and apparently consisted of both urates and oxalates.

A Bay Duiker (*Cephalophus dorsalis*) died from chronic interstitial nephritis associated with nephrolithiasis. In this case there were over a dozen minute calculi (renal sand) embedded in the calices and lying free in the pelvis, which were severely inflamed. The right kidney was much contracted, its surface puckered, and it resembled a small walnut in shape and size. There was much fibrosis of both kidneys, sclerosis of arteries and cortical glomeruli, cystic dilatation of the tubules, and degeneration of the renal epithelium.

A Swamp Deer (*Rucervus duvaucelii*) that had been eighteen years in the Gardens was killed by order as unfit for exhibition. The kidneys were cystic, contracted, deep red in colour, tough and fibrous on section. Both kidneys were surrounded by hard stony nodules of calcified fat. Apparently phosphates and carbonates of calcium had been deposited in portions of devitalized and necrosed fatty tissue. Microscopical examination of the kidneys showed great proliferation of fibrous tissue, sclerosis of renal arteries, cystic dilatation of the renal tubules, hyaline degeneration of the tubular epithelium, and glomerular tufts. Fibrotic changes in the liver of this animal were accompanied by remarkable cystic dilatations and proliferation of the bile-capillaries, which gave rise to grey spongy areas in the liver substance.

A Wolf (*Canis lupus*) was killed by order as suffering from the clinical symptoms of kidney disease. The morbid anatomical appearance of the kidneys was that of chronic parenchymatous nephritis. The capsule could not be separated from the small and contracted kidneys without tearing away part of their substance. The kidneys were removed and portions fixed immediately after death. Histological examination showed parts of the kidney where its normal structure had been entirely replaced by fibrous tissue. The glomeruli were not destroyed to any great extent, but the cytoplasm of the tubular epithelium had undergone disintegration and the cell nuclei had largely disappeared.

A Black Rat (*Rattus rattus*), the last of a batch of four, all of which succumbed to renal disease, died from impaction of a renal calculus the size of a hemp-seed in the right ureter, and consequent cystic dilatation of the pelvis of the organ. There was also a considerable amount of "renal sand" in the medullary substance.

In the other three rats renal cysts were associated with fibrosis or nephritis of the chronic interstitial type. In two cases a large renal cyst had ruptured into the peritoneal cavity and caused secondary peritonitis. A *Leptospira icterohæmorrhagiae* infection was suspected, but could not be confirmed by finding the *Leptospira* microscopically.

A Sumatran Porcupine (*Hystrix longicauda*) that had been eight years in the Gardens died from nephritis. The kidney was pale in colour and cystic throughout, and there was no differentiation between cortex and medulla. Microscopical examination revealed an interstitial nephritis with extensive round-cell infiltration, proliferation, and commencing fibrosis of the interstitial tissue. There was thickening of Bowman's capsule and atrophy of the glomeruli and tubules; many of the latter were distended to form cysts. No arteriosclerosis was observed.

In more than half the cases of avian nephritis the inflammatory conditions found appeared to have originated as defects in elimination resulting in renal constipation and clogging of the urinary tubules and ureters with semi-solid, or even solid, white deposits of urates. In such cases the kidneys are usually enlarged and dirty yellow in colour, and hæmorrhages may be seen in the soft and friable tissue, which in some cases shows evidence of fatty or lipid degeneration. The condition is sometimes associated with anæmia and œdema of the lungs; and the serous membranes of the heart and abdominal viscera may appear to be whitewashed with a film of urates which quickly dissolve away in preservative fluids. Septic infection and pyelonephritis is an occasional complication.

Microscopically the lesions are seen to vary in extent, but may be summarized as follows:—

Degeneration changes, hyaline, fatty, or lipid, are conspicuous, and affect mainly the tubular epithelium; or the tubules may be devoid of epithelium and dilated to form cysts filled with amorphous material and pus cells. Around the radicles of the ureters there is usually much inflammatory reaction, and areas of necrosis or proliferation of fibrous tissue may be seen extending along the adjacent intertubular spaces. Arteriosclerosis is not often found in this form of nephritis.

Among the birds thus affected the following species may be mentioned:—A Javan Hawk-Eagle (*Spizaetus limnaëtus cirrhatus*), Stanley Crane (*Tetrapteryx paradisea*), Cattle Egret (*Bubulcus coromandus*), Great American Egret (*Herodias egretta*), Heron (*Ardea cinerea*), African Tantalus (*Pseudotantalus ibis*), Pileated Guan (*Penelope pileata*), White-tailed Jay (*Cyanocorax mystacalis*), Rosella Parrakeet (*Platycercus eximius*), Japanese Hawfinch (*Eophona personatus*), Common Pheasant (*Phasianus colchicus*), three Malay Orange Flower-peckers (*Dicæum trigonostigma*), Raven (*Corvus corax*), Silver Gull (*Larus nove-hollandiæ*), Kite (*Milvus milvus*), Ruff (*Philomarchus pugnax*), an Oystercatcher (*Hæmatopus ostralegus*), a Blue Turaco (*Corthæala cristata*), and a Sun-bird (?).

The following cases of kidney disease in birds may also be noted:—

An Australian Cassowary (*Casuarus casuarus johnsoni*) died from chronic nephritis associated with myocarditis and myocardial infarction. There were patches of fibrotic tissue in the upper lobes of both kidneys. Microscopic examination revealed extensive fatty and colloid degeneration of the renal epithelium in tubules and glomeruli. The glomerular tufts were frequently absent from Bowman's capsules, which were distended to form cysts filled with amorphous material.

A Gold Pheasant (*Chrysolophus pictus*) died from extensive cystic disease of the kidneys associated with fibrosis and senile changes in other organs and

structures. The cysts in this case were the size of large peas and contained clear fluid.

A series of seven remarkable cases of avian nephritis affecting wild pheasants was sent for examination during the summer from an estate in Norfolk where many adult pheasants had been picked up dead. The kidneys in all cases examined were greatly and uniformly enlarged, pale buff in colour, with hæmorrhagic mottlings. Microscopic examination of sections revealed intense inflammatory reaction around the glomeruli and tubules, the epithelium of which was desquamating and degenerated. The only other lesions found in the body were small extravasations of blood in the areolar tissue of the thorax and abdominal cavities and in the serous membranes of some of the cases.

The possibility of chemical poisoning was excluded. The morbid anatomical findings, especially the nephritis, seemed to point to fowl plague as a possible cause of the epizootic. Unfortunately there was no clinical history of the disease nor opportunity to confirm this tentative diagnosis by animal tests for the virus, and it was not possible to obtain nervous tissue sufficiently fresh to permit of neuro-pathological investigation.

Renal disease in Reptiles, apart from helminthic infection, is not common ; only two cases are recorded—a Grass Snake (*Ophiocaudus apus*) and a Long-nosed Viper (*Vipera ammodytes*) ; both died from septic pyelonephritis.

Diseases of the Generative System accounted for the deaths of 4 Mammals, 11 Birds, and 11 Reptiles. Of the Mammals an African Brush-tailed Porcupine (*Atherurus africanus*) and a Mouflon (*Ovis musimon*) died in labour. A Puma (*Felis concolor*) died from septic metritis ; the uterine mucosa was severely inflamed and ulcerated and the cornua were infiltrated with pus. A Californian Ground Squirrel (*Citellus*) died from cystitis, with secondary abscesses in the prostate and seminal vesicles, which had burst into the peritoneal cavity.

All the birds and most of the reptiles died from egg-binding or its secondary complications, salpingitis, and septicæmia due to necrosed ova, or to rupture and escape of egg-contents into the peritoneal cavity.

Three viviparous reptiles died as a result of retention of dead fetuses in the genital tract.

Diseases of the Liver and Gall-bladder.

4 Mammals, 6 Birds, and 1 Reptile died from fatty degeneration of the liver—the commonest liver disease in the Gardens.

A Diana Monkey (*Cercopithecus diana*) died from gall-stones, cholecystitis, and impaction of a gall-stone in the cystic duct. The gall-bladder was distended with mucous and contained several small greenish calculi of cholesterolin and bilirubin-calcium. The liver was firm and fibrotic and was dotted throughout with small greyish spots which proved to be necrotic foci. There was also an infarct in the left lung.

Two Mammals, a Viscacha (*Viscacia viscacia*), a Mouflon (*Ovis musimon*), died from cholecystitis, secondary infection of the biliary channels, and hepatitis.

A Dourocouli (*Actes felinus*) and a Reindeer (*Rangifer tarandus*) died from abscess of the liver ; in the former case the abscess was pyæmic and secondary to inflammation of the rectum, in the latter an eroded metal pin about 2 inches long was found in the pus from a large hepatic abscess.

A Sulphur-crested Cockatoo (*Kakatoe galerita*) died from biliary cirrhosis associated with general dropsy of the tissues, ascites, and pericardial effusion. The liver was pale, hard, shrunken, and nodular, and consisted mostly of fibrous tissue.

Two Snakes and a Monitor died as a result of abscesses of the liver. Multiple military abscesses of the liver are common in reptiles. They are not unlike helminth cysts, but can be distinguished by histological examination.

Diseases of Glands and Internal Secretion.

Hyperplastic enlargement of the thyroid gland is not uncommonly found in association with other diseases directly causing death in small carnivores such as civets, foxes, and others. Thyroid disease in herbivorous animals is uncommon.

The following case in a Coypu (*Myocastor coypus*) is therefore perhaps worthy of note. The case presented an extreme degree of cystic degeneration of both thyroid and thymus glands. The former was about the size of a tangerine orange and in appearance resembled a cluster of small purple grapes, the vesicles being filled with dark red fluid. Microscopical examination showed interstitial inflammation and papillomatous proliferation of the vesicular epithelium into the lumina of the cysts. The adrenals in this case were also very large, an enlargement due to hyperplasia of the medulla and engorgement of the medullary sinusoids.

Only one case of thyroid disease was found in a bird. A Budgerigar (*Melopsittacus undulatus*) died from pulmonary hæmorrhage apparently caused by pressure and displacement of the structures of the neck by relatively enormous thyroids the size of big peas. On microscopic examination they showed cystic degeneration of the thyroid vesicles, which were filled with blood and cell débris; the greater part of the glandular enlargement, however, consisted of parathyroid tissue.

Neoplastic Diseases.

A Grison (*Grison furax*) died from a tumour affecting nearly the whole of the right lobe of the liver. The tumour was somewhat larger than a cricket ball, its surface was uneven, due to projecting blood cysts and cancerous nodules. On section the liver tumour was seen to blend intimately with the parenchyma. It was dark in colour and held together by a fibro-reticular structure. In the centre were large cavities filled with blood clot. The gall-bladder was shrunk and atrophied, and the bile-ducts were involved in the growth which obliterated the portal fissure. There was no great enlargement of any of the hepatic abdominal or other glands, and no metastases could be found in any other organs or structure. The blood was thin and watery and all the tissues were anæmic.

Histological examination: the sections show areas of necrosis and fatty degeneration lying amidst a homogeneous mass of polyhedral cells with granular cytoplasm and nuclei irregular in size and broken, but showing no mitosis. The cells are arranged in irregular clumps or in long strands with sinusoids between them, but the radiating columns characteristic of liver tissue are not evident. No portal tracts, with bile-duct, artery, and vein, can be found in the growth. There are, however, numerous sinusoids, capillaries, and thin-walled blood-vessels supported by scanty connective-tissue stroma in which there are extensive hæmorrhages. No cirrhosis is present and there are no metastatic deposits found in the hepatic lymph-glands.

The tumour is diagnosed as a liver-cell carcinoma.

A Black-backed Squirrel (*Sciurus hypopyrrhus*) died from the effects of a uterine tumour. The body of the uterus was dense and fibrous; its lumen seemed to be occluded, and the two cornua were consequently distended with retained secretion. Growing from the extremity of the right uterine cornu

there was a tough fibrotic tumour about the size of a walnut. The ovaries were atrophied and the Fallopian tubes shrunk.

Histological examination of sections of the tumour revealed a neoplasm of fibro-myomatous structure in which fibrous elements, interspersed with a few wisps of muscle, predominate. Part of the tumour shows gland-tubules with cystic dilations embedded in a cellular stroma. A few mitotic figures can be seen, but in the absence of metastases or of infiltration it is doubtful if this tumour can be classified as malignant, though it was undoubtedly the cause of death.

A Palm Squirrel (*Funambulus palmarum*) died from a remarkable hæmorrhagic and hyperplastic enlargement of the mesenteric glands. The swollen glands formed, relative to the size of the animal, enormous tumours that distended the abdominal cavity displacing and compressing all other organs; they were soft, friable, and hæmorrhagic, the largest about the size and colour of a mulberry. Sections of the glands showed much hæmorrhage amongst closely-packed lymphocytes and inflammatory cells with broken-up nuclei. The condition was associated with a severe anæmia, which, however, was not a leukæmia. The tumour-like overgrowth of the mesenteric glands was inflammatory in nature, probably due to bacterial infection.

A Triton Hamster (*Cricetulus triton*) died from septic infection and necrosis of a large lipoma growing from the subcutaneous fat of the left temporal region of the head. Microscopic examination of sections of the tumour showed areas of fat, necrosed tissue, pus, and other inflammatory cells infiltrating the adjacent muscle fibres.

The only avian case of malignant neoplasm occurred in a Bank Myna (*Acridotheres ginginianus*) that died from a tumour of the pancreas measuring about $\frac{3}{4}$ inch long and $\frac{1}{2}$ inch broad. The tumour was white in colour and of firm consistency. Similar deposits were found in the liver. Microscopical examination of sections revealed the growth to be an acinous carcinoma, and the deposits in the liver were secondary growths of pancreatic gland tissue infiltrating the hepatic structure. No metastases were found elsewhere.

Diseases of Bone.

A Sacred Baboon (*Papio hamadryas*) was affected with a curious almost symmetrical overgrowth of cancellous bone in the maxillæ. The growth from the right superior maxilla extended into and distorted the right nasal cavity.

Microscopic examination of the growth showed a normal condition of the periosteum and the compact bone immediately beneath it; but the cancellous tissue was much overgrown though uniform in structure, and no evidence of inflammatory change was detected. The bones of the calvarium were thicker than normal through overgrowth of the cancellous portion. No skeletal abnormality was found elsewhere. The condition bore some resemblance to the human disease affecting the skulls of West African negroes known as Goundou, or to Leontiasis ossium, a more common disease of Europeans. A similar disease affecting the skull-bones of apes, monkeys, and in a pony has been recorded. The cause is unknown.

I am indebted to Dr. H. A. Harris, of University College, and to other pathologists for opinions on the case.

A Virginian Opossum (*Didelphis marsupialis virginiana*) was killed by order as it could not close its mouth or feed because of hard symmetrical bony tumours growing from the alveolar processes of both jaws. Microscopical examination showed the tumour to consist of uncalcified tissue having the structure of bone,

i. e., osteoid tissue. The healthy teeth and the absence of any inflammatory phenomena distinguish this condition from chronic hypertrophic gingivitis. The disease is of interest because it is said to be the usual cause of death of this species in the Gardens. In this case there was no thickening of the calvarium nor any osseous lesion found elsewhere in the skeleton.

Dr. Counsell, of the Bland Sutton Institute of Pathology, kindly examined this bony tumour, and expressed the view that it was a rare condition apparently allied to rickets, and was conceivably a diet deficiency disease.

Bony tumours in birds are not common; the following case is therefore noted:—

A Brahminy Kite (*Haliastur indus*) died from the pressure effects of a cancellous exostosis the size of a golf ball, arising from the angle of junction of the keel with the body of the sternum, and expanding laterally and posteriorly to the displacement and distortion of the abdominal viscera.

Diseases of Areolar Tissue.

Inflammatory and septic conditions of the connective tissue following lesions of the skin or the mucosa of the external openings of the body caused the deaths of 6 Mammals, 8 Birds, and 11 Reptiles. The most important loss from this cause was that of a Lion (*Felis leo*) that had been seven years in the Menagerie, and died from spreading traumatic gangrene following on comparatively insignificant skin wounds inflicted on the inner side of the thigh by the claws or teeth of its companion. The wounds were foul and sloughing, and on opening them up the subcutaneous tissues and superficial muscles were greenish black in colour, gassy, and gangrenous. The gangrenous inflammation had spread around the perineum and along the abdominal muscles, infecting the peritoneum and causing an acute septic peritonitis and gangrene of the omentum.

All but two of the birds that died from this cause were long-legged wading birds, Egrets, Herons, etc., or Penguins that spend most of their time standing on concrete in their aviaries, and, in consequence, suffer from cracks and abrasions of the soles of their feet. A spreading cellulitis extending up the legs and ending in general septicæmia destroys the bird.

Of the reptilian cases under this heading eight snakes died from septic stomatitis and necrosis of the jaw-bones. The remainder succumbed to septic infection of the subcutaneous tissues and general septicæmia following excoriations of the skin due to bites by cockroaches or companions, or to mycotic infection of the epidermal tissues.

Diseases of the Nervous System.

A Rhesus Monkey (*Macaca mulatta*), suffering from severe and incurable paralysis (*Ataxia paraplegia*), affecting chiefly the hind limbs, was killed by order as being unfit for exhibition. No lesion visible to the naked eye was detected in the brain or spinal cord, which was kindly examined histologically by Dr. J. R. Perdrau, of the National Institute of Medical Research, who diagnosed the disease as "Schilder's encephalitis periaxialis diffusa*."

Fortunately Dr. Perdrau had at the same time a human case of a similar condition for purpose of comparison.

The demonstration of a natural infection in a monkey of this obscure disease is a matter of considerable importance to those engaged in research work on human encephalitis.

* Perdrau, J. R., 'Journal of Pathology and Bacteriology,' vol. xxxiii. No. 4, 1930.

A case of cerebral abscess in a bird, a Crow Tit (*Suthora galaris*), is perhaps of sufficient rarity to note. The whole of the left cerebral hemisphere of this bird was converted into an abscess-cavity. The cranial vault, aural and nasal passages appeared to be normal, and there was no obvious cause for the abscess.

Infections of Unknown Origin.

Hæmorrhagic septicæmia caused the death of a Sable Antelope (*Hippotragus niger*). At autopsy, about six hours after death, the blood and all the tissues were found infected with a large gas-forming anærobic bacillus with rounded ends and a central spore (? *B. welchii*). The morbid anatomy was typical of hæmorrhagic septicæmia. No external or internal wound was found, but the animal had over-eaten itself shortly before death, and the stomach was over-distended with food.

Diseases due to Disorders of Nutrition and Metabolism.

As a result of recent biochemical, biophysical, and medical research into the problem of nutrition the list of so-called accessory food factors, whether organic or inorganic in origin, is undergoing amplification. More importance in relation to the ætiology of certain diseases is now attached to the lack of one or more of these obscure factors.

In these reports, however, no disease is included under the above heading that is not so classified in the Official Nomenclature of Diseases. Defects in nutrition resulting in the so-called deficiency diseases are not uncommon among certain species in our Menagerie.

Rickets and allied diseases of bone caused the death of twenty-six Mammals during the year. It is noteworthy, however, that out of twenty-six cases eleven occurred in animals that were presented to the Society or were received in exchange from other collections in a rickety condition from which they died within six months of their arrival. Seven animals similarly acquired by the Society died from advanced rickets within twelve months, and I have reason to believe that these also were rickety on arrival. With a view to eliminating rickets so far as is practicable a careful examination is made of all susceptible species that are offered to the Society, and any rickety specimens are declined unless they have been received from donors or collectors abroad, in which case every effort is made to save them by appropriate treatment; but, if the disease is advanced and deformities are extensive, cure is impossible.

A certain number of case, however, notably in Squirrels and the lower Primates, possibly half a dozen in all, originated in the Gardens, and in a litter of wolf pups that were killed by the mother I observed signs of infantile scurvy or scurvy rickets.

Rickets acquired in the Gardens usually occurs in home-bred animals or in those captured very young and hand-reared on food that is a poor substitute for mother's milk or for the solid food that they instinctively select in nature. The disease is seen mostly in South American Monkeys, Civets, Squirrels, and certain small Carnivora, and since it can usually be recognized and studied in the living animal there is in our Menagerie an opportunity for treatment of this disease by the application of those principles of dietetics and hygienics which in medical and veterinary practice has proved in its results to be one of the outstanding successes of scientific medicine.

Among notable cases of rickets the following may be mentioned :—

Five Hedgehogs (*Erinaceus europæus*), all presented animals, that had been

kept in confinement by their owners, showed the most advanced degree of osteomalacia and rickety deformity of spine, ribs, and long bones that I have seen in any animal. They all died two months after arrival, and are examples of very severe rickets in an indigenous species of crepuscular or nocturnal habits which in its native hedgerows produces its accessory food factors in the laboratory of its own body without the aid of ultra-violet or other light rays, except perhaps, "sky-shine," but in captivity rapidly falls victim to the severest form of diet-deficiency disease. A study of the natural diet of this and other native mammals, such as foxes, during the four seasons of the year might guide us in selecting an antirachitic diet for some of our menagerie animals.

An Orang-utan (*Pongo pygmaeus*) that arrived when about a year old and had been in the Gardens 20 months, died from diet-deficiency disease, as indicated by rickets and osteomalacia affecting all the skeletal tissues. The deficiency of calcium salts was most marked in the skull, the bones of which were very light and soft. In this case the disease was probably due to the animal having been taken from its mother at a very early age.

Two Capuchin Monkeys (*Cebus fatuellus* and *Cebus apella*) arrived in a rickety condition; after a while they developed paresis and apparent incoordination of the hind limbs, but there was no absolute paralysis or spastic condition. They did not improve, and were killed by order at the request of Dr. Hurst, a research worker in Neuropathology, who was anxious to obtain material for comparison with similar material from human sources.

Dr. Hurst has supplied the Prosectorium with beautifully stained preparations of the nervous system from these cases, but they show no lesion. It would appear that the paretic condition associated with the avitaminosis in these cases was functional and due to the pain and weakness in the rickety joints. More cases must be examined, however, as it is believed that definite nerve lesions do occur in some cases of the kind.

A Hippopotamus (*Hippopotamus amphibius*), a male that was bred in the Amsterdam Zoological Gardens in 1916 and had been eleven years in the London Zoo, died from progressive wasting and debility. It had been ailing "on and off" for about two years, and was not happy with its female companion.

The only lesions found were in the skeleton. Apparently the animal had suffered severely from rickets and osteomalacia. There was pronounced "keeling" of the chest, the thorax was narrow, and the sternum pushed forwards by the irregular curvature of the ribs. The ribs showed a well-marked "rickety rosary" and many bony swellings, possibly old greenstick fractures, of the shafts. The ribs were very brittle and could be snapped easily. The medulla was bright red, hyperæmic and hyperplastic, and the bony portion of the shaft was very thin. The history of the animal indicates that it was inbred.

An Argentine Grey Fox (*Pseudalopex griseus*) that was killed by order on account of Pseudoparalysis of the hind limbs, was found on stripping the skeleton to be suffering from scurvy rickets. Subperitosteal hæmorrhages and hæmorrhage into the bladder were noteworthy scorbutic features of the case, a not uncommon finding in young Canidæ. There was great enlargement of the epiphyseal ends of the femora and tibiæ, the shafts of all the long bones were exceedingly thin, soft, and easily fractured, and the bone-marrow was unduly vascular.

Prevention of Rickets.

In our Zoological Gardens it is not possible to apply the methods of precision that are practised in undertaking a biological assay of foodstuffs in a modern

dietetic laboratory. Our attempts at the prevention of disease on dietetic principles in a mixed collection of animals are necessarily empirical and somewhat haphazard. We must feel our way by trial and error, and if we find an animal apparently so foolish as to refuse to take our vitamins we must assume that perhaps, after all, the creature knows best what is good for it, and that we are perhaps ignorant and foolish in offering stuff that its body cannot use. However, since considerable losses among Civets and young Canidæ are due to rickets and associated morbid conditions attributable to deficiency in accessory food factors, a scale of diet for animals of this order, based on that adopted in the farming of Silver Fox for the fur trade in Canada, has been drawn up in consultation with Dr. Ververs and Mr. Seth-Smith. The diet, as below specified, with appropriate modifications for various species, is now being fed to animals liable to certain diseases which experience in the Gardens (and elsewhere) has shown are preventable. The principle aimed at is to supply the requisite fruits and salts of the earth in the most economical, natural, and appetising form, and to give them opportunity to enjoy sunshine or "sky-shine" as they may feel inclined and as the weather permits.

*Diet for growing Prairie Wolf or Fox Pup or for
Breeding Pairs.*

A.M. Whole meal bread broken and softened with milk, 3 oz. Yeast mixed with bread, 1/16 oz.

P.M. Meat (according to size of animal), say 1 lb.

During the summer months 1 oz. of uncooked green vegetables, cabbage, or young turnip-tops, or young beet-tops are mashed up into fine pulp and minced with a portion of the meat ration, and given every day.

In the autumn and winter pulped carrot or swede roots is fed in about the same quantity.

Cod-liver oil $\frac{1}{2}$ oz., given daily, in a portion of chopped or minced meat.

Knuckle-bones or ribs of goat are given twice weekly for the animals to gnaw.

The bread, vegetables, and yeast preparation are given minced with a portion of their allowance of meat.

For Civets and small Carnivora a similar diet is given in smaller proportions, varying the meat ration with fish, or a sparrow or two occasionally.

Since November 17th three pairs of Foxes and three pairs of Wolves, and one pair of Jackals, which it is hoped may breed, have been fed on the diet suggested, and they eat the ration greedily.

Three pairs of Wolves and one pair of English Foxes will not touch the ration, and it is no longer fed to them.

It is too early as yet to record the effect of this diet.

A ration of vitamin-containing substances, cod-liver oil, carrots, lettuce, eggs, and minced meat is being fed daily to certain delicate species of South-American monkeys that are particularly susceptible to rickets, and an opportunity has now occurred of treating an early case of rickets in a monkey with an anti-rachitic diet plus radiation with ultra-violet light. Experience has proved that cases of advanced rickets with pronounced bone deformity are not benefited by dietetic treatment.

Death caused by Animal Parasites.

All helminthological material has been sent as usual to the London School of Tropical Medicine and Hygiene for study and identification by a panel

of experts working under the direction of Professor Leiper, F.R.S., to whom I am indebted for valuable advice and information.

The gross pathological lesions found in cases of deaths due to helminthiasis are noted below.

Helminthiasis was the direct cause of death in 10 Mammals, 20 Birds, and 31 Reptiles, and may be tabulated thus :—

MAMMALS.

| <i>Species of Host.</i> | <i>Class of Parasite.</i> | <i>Tissue affected.</i> | <i>Lesion.</i> |
|---|--|--|--|
| Bicolor Squirrel (<i>Ratufa bicolor</i>) | Nematoda, Cestodea. | Liver, duodenum. | Cholangitis, hepatitis, and cirrhosis of liver. Catarrh of in- testine. |
| Babirussa (<i>Babirussa babyrussa</i>) | Cestoda. | Lungs, liver, and spleen. | Pleurisy; cysti- ceri in lungs. |
| Canadian Porcupine (<i>Erethizon dorsatum</i>). | Filariasis. | Adult worms in subcutaneous tissues. Micro- filaria in blood. | No macroscopic lesion in tissues. Wast- ing and debility. |
| | Cestoda and Nematoda. | Intestine. | |
| Crab-eating Monkey (<i>Macaca irus</i>) . . . | Nematoda. | Stomach, large intestine. | Inanition. |
| Grizzled Grey Tree-Kangaroo (<i>Dendro- lagus inustus</i>). | Trematoda. | Liver, bile-ducts, peritoneum. | Peritonitis, cirrhosis, cholecystitis. |
| Humboldt's Woolly Monkey (<i>Lagothrix humboldtii</i>). | Nematoda. | Liver, gall- bladder, bile- ducts, duodenum. | Peritonitis, cholangitis, hepatitis, duodenitis. |
| Kinkajou (<i>Potos flavus</i>) | Nematoda. | Lungs. | Pulmonitis. |
| Large Indian Civet Cat (<i>Viverra zibetha</i>) . | Helminth cysts, Nematoda. | Upper half of ali- mentary tract, small intestine. | Colitis. |
| Persian Gazelle (<i>Gazella subgutturosa</i>) . | Helminthic cysts, Taenia. | Liver and lung. | Hepatitis. |
| Sumatran Porcupine (<i>Hystrix longicauda</i>) . | Cestoda (<i>Cenurus</i>), Cysticercus. | Thoracic muscles. | Unable to walk on account of large cyst, inanition. |

BIRDS.

| | | | |
|---|--------------------------------------|-----------------------------|---|
| Three Brazilian Hangnest (<i>Icterus jamacai</i>). | Microfilaria. | Blood. | Mass infection. |
| Brazilian Hangnest (<i>Icterus jamacai</i>) | Nematoda (larval). | Blood. | Mass infection. |
| Bifasciated Sun-bird (<i>Cinnyris micro- rhynchus</i>). | Microfilaria. | Blood. | Mass infection. |
| Black-capped Lory (<i>Domicella lory</i>) | Cestodea. | Intestine. | Catarrh of intestine. |
| Cattle Egret (<i>Bubulcus coromandus</i>) | Nematoda. | Proventriculus, gizzard. | Gastritis. |
| Two Fulvous Tree Duck (<i>Dendrocygna fulva</i>). | Filariasis. | Heart. | Adult worm in right ventricle. |
| Harlequin Quail (<i>Coturnix delegorguei</i>) . . . | Nematoda, Syngamus trachealis. | Trachea. | Suffocation, anemia. |
| Malay Orange-bellied Flower-pecker (<i>Dicaeum triginostigma</i>). | Cestodea. | Duodenum. | Perforation of duodenum, peritonitis. |

BIRDS (*con.*).

| <i>Species of Host.</i> | <i>Class of Parasite.</i> | <i>Tissue affected.</i> | <i>Lesion.</i> |
|---|---------------------------|---|--|
| Mexican Jay (<i>Xanthoura luteosa</i>) | Microfilaria. | Blood. | Mass infection. |
| Occipital Blue Pie (<i>Urocissa melanocephala</i>). | Microfilaria. | Blood. | Mass infection. |
| Orange Weaver-bird (<i>Pyromelana franciscana</i>). | Nematoda. | Air-sacs. | Inflammation of anterior intermediate air-sac. |
| Ornate Lorikeet (<i>Trichoglossus ornatus</i>) | Cestodea. | Intestine (small). | Intestinal catarrh. |
| Peregrine Falcon (<i>Falco peregrinus</i>) . . . | Filariasis. | Adult worms in air-sacs, microfilaria in blood. | Mass infection, microfilaria in blood, wasting. |
| Peregrine Falcon (<i>Falco peregrinus</i>) | Nematoda. | Abdominal air-sac. | Inflammation of air-sac and peritonitis with effusion. |
| Red-collared Barbet (<i>Cyanops henrici</i>) . . | Cestodea. | Intestine. | Catarrh of intestine. |
| Rufous-tailed Pheasant (<i>Acomus erythrophthalmus</i>). | Helminth cysts. | Cæca. | Inflammation of cæca. |
| Wrinkled-billed Hornbill (<i>Cranorhinus corrugatus</i>). | Filariasis. | Adult worm in air-sacs, microfilaria in blood. | Mass infection, microfilaria in blood, wasting. |

REPTILIA.

| | | | |
|--|---|--|---------------------------------|
| Æsculapian Snake (<i>Elaphe longissimus</i>) . . . | Nematoda. | Œsophagus, stomach, small and large intestines. | Anæmia. |
| African Python (<i>Python sebae</i>) | Nematoda, Cestoda, Arachnida (<i>Porocephalus</i>). | Pylorus, duodenum, lung. | Colitis and gastritis. |
| Black and Gold Tree-Snake (<i>Boiga dendrophila</i>). | Nematoda and ? (Cysts). | Nematoda in lung and intestine, cysts in lung and intestine. | Pulmonitis, intestinal catarrh. |
| Broad-headed Water-Snake (<i>Homalopsis buccata</i>). | Nematoda. | Intestine, serous membranes, alveolar tissues. | Enteritis. |
| Three Dark Green Snakes (<i>Coluber gemonensis</i>). | Nematoda. | Lung. | Pulmonitis. |
| Four-lined Snake (<i>Elaphe quatuorlineatus</i>). | Nematoda. | Lung, intestine. | Pulmonitis. |
| Four-lined Snake (<i>Elaphe quatuorlineatus</i>). | Nematoda. | Gut from œsophagus to first part of small intestine. | ? Inanition. |
| Four Glass Snakes (<i>Ophiosaurus apus</i>) . . . | Nematoda. | Lungs. | Pulmonitis. |
| Diamond Rattlesnake (<i>Crotalus adamanteus</i>). | Arachnida (<i>Porocephalus</i>). | Trachea, lung. | Anæmia. |
| Gray's Temple Viper (<i>Trimoresurus purpureomaculatus</i>). | Cestodes, Arachnoides (<i>Porocephalus</i>). | Lungs, intestine. | Pulmonitis |
| Gray's Temple Viper (<i>Trimoresurus purpureomaculatus</i>). | Cestodes. | Intestine. | Enteritis. |

REPTILIA (con.).

| Species of Host. | Class of Parasite. | Tissue affected. | Lesion. |
|--|---|------------------------------------|--|
| Gray's Temple Viper (<i>Trimeresurus purpureomaculatus</i>). | Cestodes. | Intestine. | Anæmia. |
| Green Tree Boa (<i>Boa canina</i>) | Arachnida (<i>Porocephalus</i>), Cestoda, Nematoda. | Lung, large intestine. | Pulmonitis. |
| Hamadryad (<i>Naja hannah</i>) | Arachnida (<i>Porocephalus</i>). | Œsophagus, body-cavity. | Anæmia. |
| Three Indian Cobras (<i>Naja naja</i>) | Arachnida (<i>Porocephalus</i>). | Lung. | Pulmonitis. |
| Indian Rat Snake (<i>Ptyas mucosus</i>) | Arachnida (<i>Porocephalus</i>). | Lung. | Pulmonitis. |
| King Snake (<i>Lampropeltis getulus</i>) | Nematoda. | Lung. | Pulmonitis. |
| Nose Horned Viper (<i>Bitis nasicornis</i>) | Arachnida (<i>Porocephalus</i>), Nematoda. | Lung, intestine. | Pulmonitis. |
| Mocassin (<i>Akistrodon piscivorus</i>) | Arachnida (<i>Porocephalus</i>), Cestodea. | Lung. Intestine. | Abscess of lung. Pyæmia. |
| Papuan Python (<i>Liasis papuanus</i>) | Nematodes. | Intestine, infestation of lungs. | Perforation of intestines, peritonitis, pulmonitis. |
| Surinam Lizard (<i>Amieva festiva</i>) | Nematoda cysts. | Stomach, body-cavity, peritoneum. | Mass infection of liver, body-cavity, and peritoneum, with helminth cysts. |
| Say's Toad (<i>Bufo cognatus</i>) | Helminth cysts. | Areolar tissue about cardiac base. | Pericarditis, myocarditis. |
| Say's Toad (<i>Bufo cognatus</i>) | Nematoda. | Lungs. | Pulmonitis. |
| Southern American Poison Frog (<i>Dendrobates tinctorius</i>). | Nematoda. | Intestine. | Enteritis. |
| Tigrine Frog (<i>Rana tigrina</i>) | ? | Liver, mesentery, peritoneum. | Cysts. |
| Viperine Snake (<i>Natrix viperinus</i>) | Trematoda. | Lung. | Pulmonitis. |

Blood Parasites.

Pathological conditions arising from mass infection of the blood with parasitic protozoa caused the deaths of 1 Mammal, 7 Birds, and 2 Reptiles. Dr. C. M. Wenyon, F.R.S., Director in Chief of the Wellcome Bureau of Scientific Research, has again kindly undertaken the examination of duplicate blood-films concurrently with the examination of blood-films carried out in the Prosectorium.

During the 12 months (January 1–December 31) 1019 slides of blood taken from dead animals were examined for blood parasites. Infections were found in 162.

A list of blood parasites compiled from Dr. Wenyon's Reports to the Society's Prosectorial Committee is given below.

| | |
|-----------------------------|-----|
| Single infections | 134 |
| Double infections | 24 |
| Triple infections | 5 |

SINGLE INFECTIONS.

| PARASITE. | HOST. |
|---------------------------|--|
| Hæmogregarines (65) | <i>Aghistodon piscivorus</i> , <i>Ahætulla picta</i> , <i>Atractus trilineatus</i> , <i>Bitis nasicornis</i> , <i>Bitis arietans</i> , <i>Boa constrictor</i> , <i>Boa imperator</i> , <i>Boiga dendrophila</i> , <i>Bungarus fasciatus</i> , <i>Chondrorython viridis</i> , <i>Coluber jugularis</i> , <i>Coluber sayi</i> , <i>Coronella boylei</i> , <i>Crotalus adamanteus</i> , <i>Crotalus horridus</i> , <i>Cyclagras gigas</i> , <i>Dendraspis viridis</i> , <i>Dispholidus typus</i> , <i>Drymobius boddaerti</i> , <i>Eteirodipsas colubrina</i> , <i>Elaphe quatuorlineata</i> , <i>Heloderma suspectum</i> , <i>Homalopsis buccata</i> , <i>Lacerta ocellata</i> , <i>Liasis papuanus</i> , <i>Naja hannah</i> , <i>Naja naja</i> , <i>Ophiocaurus apus</i> , <i>Passerita nasutus</i> , <i>Ptyas mucosus</i> , <i>Psammophis sibilans</i> , <i>Python molurus</i> , <i>Python curtus</i> , <i>Python reticulatus</i> , <i>Python sebae</i> , <i>Python spilotes</i> , <i>Rana macrodon</i> , <i>Sepedon hæmachates</i> , <i>Tupinambis teguixin</i> , <i>Varanus flavescens</i> , <i>Varanus monitor</i> , <i>Varanus salvator</i> , <i>Vipera ammodytes</i> , <i>Vipera russelli</i> , <i>Zaocys carinatus</i> . |
| Hæmoproteus (29) | <i>Ammoperdix griseocularis</i> , <i>Argusianus argus</i> , <i>Chloris sinica</i> , <i>Cinixys erosa</i> , <i>Corythæola cristata</i> , <i>Balcarica pavonina</i> , <i>Estrilda melopoda</i> , <i>Estrilda cinerea</i> , <i>Haliaetus leucorhynchus</i> , <i>Junco hyemalis</i> , <i>Munia oryzivora</i> , <i>Netta rufina</i> , <i>Ptilinopus melanocephalus</i> , <i>Phlorhynchus violaceus</i> , <i>Pyromelana franciscana</i> , <i>Speimestes cucullatus</i> , <i>Tamniopygia castanotis</i> , <i>Tanagra flava</i> , <i>Trichoglossus ornatus</i> , <i>Thraupis olivicephala</i> , <i>Trichoglossus forsteri</i> , <i>Uraginthus bengalus</i> . |
| Plasmodium (3) | <i>Callosiurus prevosti</i> , <i>Megacephalon maleo</i> . |
| Microfilaria (26) | <i>Acomus erythrophthalmus</i> , <i>Aex galericulata</i> , <i>Amandava amandava</i> , <i>Babirussa babyrussa</i> , <i>Cacatua galerita</i> , <i>Colurnia delegorguei</i> , <i>Cranorhinus corrugatus</i> , <i>Cyanerpes cyaneus</i> , <i>Dicaeum trigonostigma</i> , <i>Domercella lory</i> , <i>Erethizon dorsatum</i> , <i>Estrilda subflava</i> , <i>Hapale jacchus</i> , <i>Icterus jamaicae</i> , <i>Otocompsa emeria</i> , <i>Otus scops</i> , <i>Peophila acuticauda</i> , <i>Saimiris sciurea</i> , <i>Tangara flava</i> , <i>Poicephalus fuscicapillus</i> , <i>Urocissa melanocephala</i> , <i>Viverra zibetha</i> . |
| Leucocytozoon (5) | <i>Pyromelana franciscana</i> , <i>Spatula clypeata</i> , <i>Suthora gularis</i> . |
| Trypanosoma (1) | <i>Poephila gouldii</i> . |
| Babesia (2) | <i>Civetictis civetta</i> . |
| Dactylosoma (1) | <i>Rana adspersa</i> . |
| Trichomonas (2) | <i>Trimeresurus purpureomaculatus</i> , <i>Trimeresurus wagleri</i> . |

DOUBLE INFECTIONS.

| | |
|--|--|
| Hæmogregarines and Microfilaria (1) | <i>Crotalus oregonus</i> . |
| Hæmoproteus and Microfilaria (5) | <i>Cyanoptila bella</i> , <i>Icterus wagleri</i> , <i>Pyromelana franciscana</i> , <i>Spizaetus cirrhatus</i> , <i>Xanthoura luzuosa</i> . |
| Plasmodium and Microfilaria (1) | <i>Calocitta formosa</i> . |
| Leucocytozoon and Microfilaria (3) | <i>Aex galericulata</i> , <i>Falco peregrinus</i> , <i>Garrulus glandarius</i> . |
| Hæmoproteus and Leucocytozoon (5) | <i>Pyromelana franciscana</i> , <i>Suthora gularis</i> . |
| Hæmogregarines and Lankesterella (3) | <i>Rana tigrina</i> . |
| Hæmoproteus and Plasmodium (1) | <i>Estrilda caerulea</i> . |
| Leucocytozoon and Plasmodium (1) | <i>Suthora gularis</i> . |
| Lankesterella and Trypanosoma (1) | <i>Rana catesbiana</i> . |
| Lankesterella and Microfilaria (2) | <i>Rana catesbiana</i> , <i>Rana macrodon</i> . |
| Trypanosoma and Microfilaria (1) | <i>Xanthoura luzuosa</i> . |

TRIPLE INFECTIONS.

| PARASITE. | HOST. |
|--|--|
| Hæmoproteus, Leucocytozoon, and Microfilaria (1). | <i>Otus scops.</i> |
| Hæmogregarines, Lankesterella, and Trypanosoma (1). | <i>Rana tigrina.</i> |
| Hæmoproteus, Trypanosoma, and Microfilaria (1). | <i>Haliastur indus.</i> |
| Plasmodium, Leucocytozoon, and Toxa- plasma (2). | <i>Liothrix luteus, Suthora gularis.</i> |

In conclusion, I wish to express further grateful acknowledgments for the valuable advice and help I have received during the year from Pathologists and Bacteriologists attached to the following Institutions :—

| | |
|---|---|
| Mr. Lovell, | } of the London School of Tropical Medicine and Hygiene. |
| Dr. Buxton, | |
| Dr. Thompson, | |
| Dr. Counsell, of the Bland Sutton Institute of Pathology, Middlesex Hospital. | |
| Dr. Mervyn Gordon, F.R.S., of the Pathological Department, St. Bar- tholomew's Hospital. | |
| Dr. Bedson, of the London Hospital. | |
| Dr. H. A. Harris, of University College Hospital. | |

My best thanks are due to Dr. Zuckerman for performing the routine post-mortem examinations in addition to his other duties during the months of November and December and since I have been deputising for Dr. Vevers as Superintendent of the London Gardens.

29. Note on the Egg of the Nile Crocodile (*Crocodylus niloticus*).

By R. BIGALKE, M.A., Ph.D., F.Z.S. (Director of the National Zoological Gardens, Pretoria).

[Received January 27, 1931 : Read April 14, 1931.]

(Text-figure 1.)

In October 1930 the Governor-General of Mozambique, Lt.-Col. J. R. Pereira Cabral, generously presented two Nile Crocodiles to the National Zoological Gardens of South Africa. The animals were captured in the neighbourhood of Moamba in Portuguese East Africa, and on arrival at Pretoria one specimen was found to measure about $9\frac{1}{2}$ feet in length and the other about 9 feet. During the night of the 19th to 20th November, 1930, one of these two crocodiles, probably the larger one, which was in better condition than the smaller one, laid a batch of forty-eight eggs in the small cement pool within the enclosure in which both animals are kept, and an opportunity was thereby afforded of examining the egg of this reptile.

Ten eggs taken at random from the batch were placed at the disposal of the Transvaal Museum, and I am indebted to Mr. V. Fitzsimons, M.Sc., for the following dimensions and weights of these eggs, determined on the 21st November :—

| No. | Longitudinal diameter. Centimetres. | Transverse diameter. Centimetres. | Weight. Ounces. |
|--------------|--|--------------------------------------|--------------------|
| 1 | 7.57 | 5 | 4 |
| 2 | 7.45 | 4.93 | 3.9 |
| 3 | 7.32 | 4.89 | 3.8 |
| 4 | 7.47 | 4.99 | 3.9 |
| 5 | 7.5 | 4.99 | 3.9 |
| 6 | 7.5 | 4.91 | 3.9 |
| 7 | 7.37 | 4.95 | 3.8 |
| 8 | 7.44 | 4.97 | 3.9 |
| 9 | 7.53 | 5.05 | 4 |
| 10 | 7.44 | 4.94 | 3.9 |

It is obvious from this table that the dimensions of the eggs examined were fairly constant, the maximum differences being .25 cm. in the longitudinal and .16 cm. in the transverse diameter. According to Gadow (1) the size of the egg varies from 5.5 to 9 cm. in length and from 4 to 5 cm. in width, and Werner (5) states that the eggs measure about 9 by 6 cm., and that females $3\frac{1}{2}$ metres in length are capable of reproducing their kind, but lay fewer and smaller eggs than full-grown specimens.

When the eggs were removed from the pool in which they had been laid, it was observed that each egg was more or less completely enveloped by a transparent jelly-like substance, presumably a product of the oviduct.

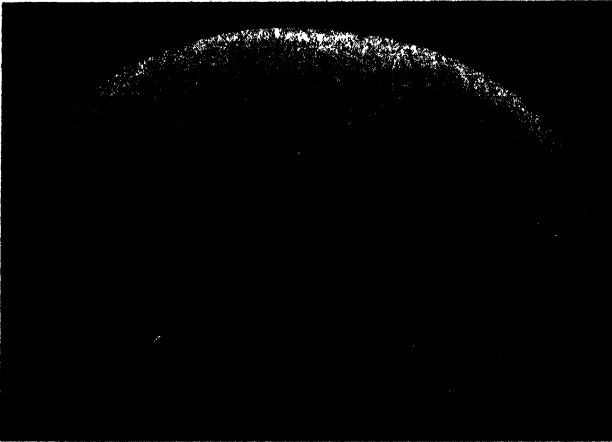
The egg of the Nile Crocodile is elliptical in shape and in most cases is equally developed at both poles, so that a narrow and a broad end cannot be distinguished as in the eggs of many species of birds. Of about a dozen

eggs examined only one tapered slightly towards one pole, the air-chamber in this instance lying obliquely across the broader pole of the egg.

The egg is enclosed in a hard, glossy, calcareous shell, which is pure white in colour. On the surface of the shell are numerous conspicuous pits clearly seen in the accompanying photograph (text-fig. 1). The pore-canals that traverse the shell open into these pits, and the latter make the surface of the egg rough to the touch. The shell is about .5 mm. thick and fairly brittle, so that it can be carefully peeled off with a scalpel.

Closely applied to the inner surface of the shell is the tough white shell-membrane. In the fowl's egg the shell-membrane is double and separates at the broad pole of the egg into two layers—a thinner inner and a thicker outer shell-membrane—the air-chamber being enclosed by these two layers. In the egg of the Nile Crocodile, however, the air-chamber does not lie between an inner and an outer shell-membrane, but between the calcareous shell and

Text-figure 1.



Egg of *Orocodylus niloticus* Laur. Natural size. The black spots are foreign matter in some of the pits.

the thick shell-membrane, and hence the nature of the latter is not as easily determined macroscopically in the crocodile as in the fowl. In the crocodile's egg a thin inner shell-membrane is closely applied to a thick outer shell-membrane, and can be separated off with scalpel and forceps from the latter. Laminae can also be split off from the outer shell-membrane, but it is probable that these do not indicate definite membranes. The glossy inner surface of the inner shell-membrane is studded with tiny calcareous crystals, except in the region of the air-chamber. In eggs which were ten days old the position of the air-chamber at one pole of the egg was clearly indicated on the external surface by the duller white colour of the area concerned. By holding such eggs against the sunlight the air-chamber could be located immediately. The position of the air-chamber is subject to variation. Thus, in two eggs ten days old it was situated at one pole at right angles to the long axis of the egg, whereas in one egg ten days old and four eggs eighteen days old it was found to lie obliquely across one pole and not at right angles to the long axis. In another

egg five days old the small air-space did not assume a transverse position at all, but lay in a plane parallel to the longitudinal axis of the egg.

The albumen is jelly-like and perfectly transparent. It is much thicker in consistency than the albumen of the fowl's egg, and hence when a crocodile egg is dissected under water the albumen and the contained yolk can be removed intact from the shell, and the whole retains its shape. Embedded in the albumen, and generally more or less concentrated at one of the two poles, are numerous tiny white specks. These were examined under the microscope, and were found to be calcareous spicules, irregularly star-shaped, with many projections. They are soluble in 10 per cent. hydrochloric acid, and after solution the form of the spicules is still clearly visible in the albumen under the microscope. Chalazæ could not be detected in the albumen.

The large yolk is of a pale cream-colour and is enclosed in a delicate vitelline membrane, which is easily ruptured when dissecting.

When an egg is boiled for some time the clear albumen becomes opaque and white, but remains more or less soft, and does not assume the same consistency as the coagulated albumen of the boiled fowl's egg. The boiled yolk retains its pale cream-colour.

REFERENCES.

1. GADOW, H. *Amphibia and Reptiles*. Cambridge Natural History, 1901.
2. KÜKENTHAL, W. *Handbuch der Zoologie*. Bd. vii. Zweite Hälfte, Aves. Berlin und Leipzig, 1928.
3. LILLIE, F. R. *The Development of the Chick*. New York, 1919.
4. SCHMIDT, K. P. Contributions to the Herpetology of the Belgian Congo, based on the Collection of the American Congo Exhibition, 1909-15. *Bull. Amer. Mus. of Nat. Hist.* vol. xxxix. art. ii. New York, 1919.
5. WEBNER, F. *Brehms Tierleben*. Lurche und Kriechtiere. Bd. i. Leipzig, 1925.

30. On some new Australian Acari (Trombidiidæ, Anystidæ, and Gamasidæ)*. By A. STANLEY HIRST, F.Z.S. (Zoological Department, University of Adelaide) †.

[Received January 6, 1930 : Read March 18, 1930.]

Family TROMBIDIIDÆ.

ALLOTHROMBIUM WASSELLI, sp. n.

Allied to *A. parvulum* Hirst (Rottnest Island, Western Australia). *Size* large. *Shape* normal, the body being longer than wide and widest anteriorly. *Body-setæ* of two distinct kinds, viz., longer club-shaped setæ with thick bushy heads, and shorter hairs which do not end in a point nor do they taper apically. These shorter hairs are clothed with fairly long accessory hairs, the latter being almost subequal throughout the length of the stem, except at their distal end, where there are a few short curved ones. *Palpal thumb* of moderate length, being club-shaped. *Tarsus* of *first leg* less than three times as long as high, being longer than the metatarsus. *Pulvillus* distinct.

Measurements.—Length of body 4.9 mm.; its greatest width (about) 3.15 mm. Length of longer hairs 93–106 μ , of shorter hairs 65–70 μ ; accessory hairlets on shorter hairs about 23 μ in length. Length of metatarsus of first leg .64 mm., of tarsus of same .80 mm. Height of first tarsus .29 mm.

Habitat.—Deep Creek, Narabeen Lakes, New South Wales, 4. viii. 1929. A single specimen collected by J. L. Wassel (Australian Museum Collection, Sydney).

MICROTROMBIDIUM ECHIDNINUM, sp. n.

Allied to *M. spinosum* Canestrini, *M. hystricinum* Can., *M. diversipile* Can., and *M. willungæ*, sp. n. *Colour* red. *Size* rather large. *Body* long oval, being about twice as long as wide. No *nasal process* anteriorly. *Front margin* of *cephalic area* with a fringe of long, slender, plumose hairs. *Lateral eyes* paired, well developed, and sessile. Sensory area of *crista* posterior in position; the two sensory structures are shaped like minute eyes, being rounded. *Dorsal body-setæ* of *abdominal* portion of two distinct types, viz., comparatively long, often naked, spiniform setæ, and very much shorter spiniform setæ clothed with hairs, except at the tip, which is naked. There are also present a few setæ intermediate between these two types. *Tarsus* (thumb) of *palp* well developed, fairly long, only of moderate width and only slightly club-shaped. *Penultimate segment* furnished with a double comb, the dorsal portion of which has short but quite well-defined teeth. *Terminal claw* well developed, and there is also a much shorter but still fairly strong accessory thorn. Besides the inner structures the tarsus has also two spines on its outer side. *Tarsus* of *first leg* apparently longer than in *M. hystricinum* Can., being nearly three and a half times as long as high.

* The expenses of this and other papers on Australian Acari have been partly paid by means of a Government grant received through the Royal Society of London.

† Publication of this communication has been delayed in the hope that the drawings for the text-figures might have been found among the effects of the late Mr. Stanley Hirst.

Measurements.—Length of body 2·6 mm., its width about 1·3 mm. Length of long bare spiniform setæ of body 222–227 μ , of smaller spinules 23–27 μ , of tarsus of first leg ·60 mm.; height of same ·19 mm. Length of metatarsus of same ·45 mm.

Habitat.—Mount Gambier, South Australia; several specimens found by the author under fallen leaves and logs of wood in valley near Leg of Mutton Lake, November 1929.

MICROTROMBIDIUM WILLUNGÆ, sp. n.

Closely allied to *M. echidninum*, sp. n., from Mount Gambier, but much smaller in size, and the relative size and also structure of the body-setæ also different. *Size* small. *Colour* red. *Body* longer than wide. *Body-setæ* of two different kinds as in *M. echidninum*, but the smaller setæ are longer in comparison with those of the species just mentioned and clothed with quite short accessory hairs. *Tarsus* (thumb) of *palp* elongated and rather slender. *Terminal claw* well developed, and it is accompanied by a fair-sized accessory thorn. Two inner *combs* are present on the *penultimate segment* of the *palp*, and there are also two slender external spines. *Tarsus* of first leg nearly three times as long as its own height, being much longer than the *metatarsus*.

Measurements.—Length of body 1·3 mm., its width (about) ·75 mm. Length of longer body-setæ 105–151 μ , of shorter body-setæ 35–45 μ . Length of metatarsus of first leg ·18 mm.; length of tarsus of same ·30 mm.; height of tarsus ·11 mm.

Habitat.—Willunga, South Australia. A single example found by the author under a log of wood near a creek, October 1929.

FAMILY ANYSTIDÆ.

TARSOTOMUS WARREGENSE, sp. n.

♀?. *Genital opening.*—There is a pair of conspicuous comb-like structures on the *venter*, one on each side of the genital slit. Each comb consists of a transverse row of 10–11 stiff, moderately thick, plumose setæ. There is also a longitudinal series of very short setæ or hairs arranged along the genital opening, the anterior ones being plain, but the posterior ones plumose, and one or two of the latter are bifurcated. *Penultimate segment* of *palp* ending in two well-developed thorns, one of which is almost twice as long as the other. *Tarsus* of *palp* long and rather slender, being furnished with long slender setæ, which are especially numerous near the distal end. *Legs* furnished with numerous hairs, some of which are fairly long. Some of the hairs on the distal segments of the anterior legs are furnished with stiff, regularly arranged, secondary setæ, which are almost comb-like in appearance. Dorsally the anterior tarsi have some fairly long, stiff, plain, tactile setæ. Paired *claws* of legs furnished with double combs. The third (unpaired) claw is very small, curved, and has slight lateral denticles. The middle claw of the last legs is a little longer than the others.

♂?. The comb-like series of hairs present on the *venter* in the female appears to be absent. There is a longitudinal series of hairs or setæ along the *genital slit*, but they are almost plain. *Tarsus* of *palp* elongated and furnished with long hairs distally. Unpaired middle *claw* of last pair of legs apparently better developed than in the female sex.

Measurements.—Length of body (about) 1·04 mm., its width about ·6 mm. Length of male ·90 mm., its width ·55 mm.

Habitat.—Bourke, and also Barrington, New South Wales, June, 1927. A few specimens found in dust and under pieces of wood near the Warrego River. Also an example of the same or a closely allied form from Charleville, Queensland.

A specimen from Barrington has been selected as type.

Note.—Although described above as the male and female of a single species, it is quite possible that two distinct species are present in the material.

Family GAMASIDÆ.

LÆLAPS HAPLOTI, sp. n.

Colour dark, all the plates of the body being formed of strong dark chitin. *Body* longer than wide and sometimes with a slight indentation in the middle posteriorly. *Sternal plate* very strongly chitinized, markings indistinct or absent. *Genito-ventral plate* also strongly chitinized and rather wide; there are no distinct markings on its surface. Four pairs of long hairs are present on this plate, those of the posteriormost pair being situated rather close together. *Anal plate* shaped as figured, the paired anterior hairs on it are quite short; the unpaired posterior hair on this plate stouter, but not long. *Coxal platelet* fairly wide. Hairs on *venter* numerous, rather fine and rather long, especially some of the posterior ones. The pair of hairs near the base of the ventral surface of *capitulum* short and quite fine. Posterior seta on first and third *coxæ* spiniform; there is also a spiniform seta on the fourth coxa, but it is placed well forwards. There are some well-developed setæ on the terminal segments of the second and third legs.

Length of body (not including capitulum) 1.31–1.33 mm.

Habitat.—Humbag Scrub, near Adelaide, South Australia. Specimens from *Haplotis* (jumping pouched marsupial mouse). Two tubes of specimens, one of which was collected by J. Rau (South Australian Museum Coll., Adelaide).

LÆLAPS (MESOLÆLAPS) LAGOTISINUS, sp. n.

Allied to *L. (M.) anomalus* Hirst and *L. (M.) australiensis* Hirst, having only three pairs of hairs on the genito-ventral plate, as in those species. *Dorsal scutum* not very wide posteriorly. *Sternal plate* normal in shape, marked with faint reticulation and furnished with three pairs of long hairs, of which the anterior pair is plumose. *Genito-ventral plate* quite narrow, with indistinct markings, and furnished with three pairs of hairs. *Anal plate* shaped as shown in figure; the three hairs on it are all long, the paired ones being longer than usual. Hairs on *venter* numerous and of moderate length. *Anterior seta* near ventral surface of first *coxa* of first and second leg spiniform. *Coxal platelet* rather elongated. Spines on *metatarsi* of legs 2–4 strongly developed, especially in the case of the second leg. Hairs near base of *capitulum* quite fine, short, and feathered.

Length of body (not including capitulum) 1.34–1.50 mm.

Habitat.—Perth, Western Australia. A few specimens from a mammal, *Thalacomys lagotis*.

SPINTURNIX ANTIPODIANUS, sp. n.

♂. *Ventral plate* with coarser markings than in *S. novæhollandiæ*, sp. n. Hairs on *venter* distributed as shown in figure.

Terminal segments of *palp* furnished with sensory setæ that are different

in size and arrangement from those present on the same segments of the palp in *S. novæhollandiæ*.

Length of body (not including capitulum) .84 mm.

Habitat.—Cairns District, North Queensland. A single male example found by Mr. A. H. Lea on a bat (South Australian Museum Coll., Adelaide).

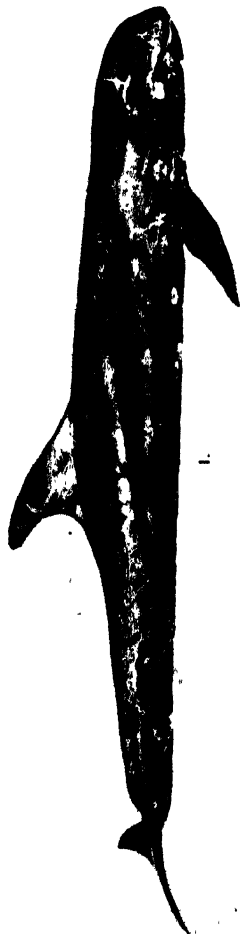
SPINTURNIX NOVÆHOLLANDIÆ, sp. n.

♀. *Ventral plates* small, especially the genito-ventral one. *Sternal plate* quite small, oval in shape, and marked with a fine reticulate pattern; three short, fine, stiff hairs are present on this plate. *Genito-ventral plate* very short, the operculum being larger than the posterior portion of it, the latter wedge-shaped in outline. *Anal plate* very small, the paired setæ on it short and subspiniform; its unpaired seta also short. Ventral portion of *peritremal tube* not supported by any distinct chitinous plate. Setæ on *venter* fairly numerous, very short, stiff, and almost spiniform. At the posterior end of the body there is a group of much longer, stiff, subspiniform setæ, which are thicker in the basal half than distally. Many of the hairs on the legs are fairly long and curved.

♂. *Ventral plate* shaped as shown in figure. Hairs on *venter* not very numerous and distributed as shown in figure.

Length of body (not including capitulum) of female 1 mm., of male .84 mm.

Habitat.—Lucindale, South Australia. Two females and one male from bat (South Australian Museum Coll., Adelaide).



1.



2.



3.

GRAMPUS GRISEUS.

31: The Occurrence of a Male and Female *Grampus griseus* (Delphinidæ)
at Sydney, New South Wales. By ELLIS LE G. TROUGHTON*.

(By permission of the Trustees of the Australian Museum.)

[Received October 21, 1930: Read March 3, 1931.]

(Plate I.)

The gradual revealing of the almost world-wide range of Risso's Dolphin or Grampus during the past century strikingly illustrates the difficulties of early nineteenth century workers with their limited view of Cetacean distribution, and the obstacles to study provided by bulk and infrequent or remote occurrences. As recently as 1918 Sir Sidney Harmer, in noting the Cetacea stranded on the British coasts during 1913-1917, refers to the decision of the Trustees of the British Museum to examine the evidence more systematically, and says that "in the majority of cases the evidence derivable from these occurrences has not been sufficiently used."

Owing to the migratory habits of most Cetaceans correlative evidence of occurrences in Australasian seas would seem to be of equal importance, especially in regard to the Grampus, as there are very numerous records of strandings in other regions during the past century, while hitherto there have been but two authentic records from Australasia.

The first, from New Zealand in 1873 †, was overlooked by True, and has been disregarded by most European authors with the exception of Van Beneden and Gervais and Trouessart. The second, from near Adelaide in 1890 ‡, had apparently been overlooked by both Australian and overseas workers until Wood Jones noted the record in 1925 in his 'Mammals of South Australia'; publication of this South Australian record a year after True's monograph appeared, coupled with the fact that the 'Zoological Record' did not quote the Grampus as being amongst the seven species listed, doubtless contributed to the record being overlooked.

Additional proof of the importance of such records in Australia is furnished by a consideration of the great tracts of uninhabited coast-line, which must cause many important occurrences to pass unnoticed, apart from the fact that in the past comparatively few local writers have been interested in such happenings.

As a preliminary to recording the second known occurrence of the Grampus on the Australian coast, represented by the recent stranding of a male and female near Sydney, a brief review of the complex history of this interesting Cetacean may prove useful, although the relevant literature is too extensive for quotation.

Subsequent to the descriptions of *Delphinus griseus* Cuvier (1812), founded upon an animal taken at Brest, and the synonymous *D. rissoanus* Desmarest (1822) from Nice, it was considered that two species existed—the former from several localities on the west coast of France and the Isle of Wight, and the latter from the Mediterranean only. The first striking extension of range

* Communicated by MARTIN A. C. HINTON, F.Z.S.

† Hector, Trans. N. Zeal. Inst. v. 1872 (1873), p. 163.

‡ Ziets, Trans. Roy. Soc. S. Austr. xiii. (1) 1890, p. 9.

occurred when Gray (1846) formally used the name *G. sakamata* for a Dolphin described by Schlegel from Japanese drawings and natural histories; this remained a somewhat doubtful record until Gervais applied the name to the skull of a Grampus received from Japan, definitely establishing its occurrence there. The second notable extension was provided by Gray (1865), who recognized a Grampus skull from Kalk (Simon's Bay), Cape of Good Hope, as identical with his *Grampus richardsoni* (1850), founded upon an unlocalized jaw presented to the British Museum.

In his famous memoir Flower (1874) confirmed Fischer's opinion that the first two species were synonymous, and remarked that *richardsoni* "differs slightly from those above described." He also quoted Fischer's far-seeing suggestion that the Grampus was migratory; and it is interesting to note that in the previous year the former's assumption that the species passed the winter either in the south towards the African coast or the west towards America was supported by Dall's description of *Grampus stearnsi* (1873), based upon two lower jaws and observations made on the Californian coast. In the same year the first Australasian record was provided by Hector (*loc. cit.*) upon a lower jaw obtained on the Manawatu Beach, New Zealand, which he regarded as apparently representative of *G. richardsoni*.

Further American records, including the first from the east coast, were furnished by Cope (1876) on specimens taken near Cape Cod, Massachusetts, and figured as *G. griseus*; also by Heilprin (1887), who "called attention to the recent stranding on the New Jersey coast, at Atlantic City, of Risso's whale *Grampus rissoanus*," which he supposed was the first record from "trans-Atlantic waters." A few years later True (1889), in his excellent review of the Delphinidæ, after traversing the characters of the various synonyms and the intergradations of their skull dimensions, in comparison with a series of four adult skeletons and ten skulls from Cape Cod, concluded that there was but a single species of Grampus. He also relegated *Globicephalus rissii*, described anonymously in the Chinese Repository (1838) from the Chinese seas, near Leuchan, and subsequently named *Globicephalus chinensis* by Gray (1866), to the synonymy of the Grampus. Thus True established the occurrence in Chinese waters, though, strangely enough, in dealing with *richardsoni* he omitted any mention of the New Zealand record.

An unauthentic record of New Zealand occurrence was provided by Waite's (1912) identification of the well-known Cetacean Pelorus Jack with *Grampus griseus*, as published in the 'Records of the Canterbury Museum.' This Cetacean, deriving its popular name from Pelorus Sound in New Zealand, became famous owing to its habit of piloting vessels through the French Pass, the public interest thereby created leading to its total protection by an Order-in-Council signed in 1904 and published in the official 'Gazette.' In the first edition of their 'Animals of New Zealand' Hutton and Drummond regarded the animal as a Beluga or White Whale, subsequently stating it to be a Goose-beak Whale (*Ziphius*) in the 1905 edition, and finally, in 1923, accepting the identification as *Grampus griseus*.

It is obvious, from the absence of the dorsal fin in the Beluga and the position of this fin in *Ziphius*, that Pelorus Jack did not represent either of these Whales, and, in my opinion, it is extremely doubtful that it was reconcilable with the Grampus. A notable point is that Waite, in his 'Guide to the Whales and Dolphins of New Zealand,' referred to it as the "White Dolphin," and whiteness appears to have been the prevailing impression of observers, whereas the bodies of the two Sydney specimens of Grampus were almost uniformly blackish; furthermore the general shape of the body, especially the triangular appearance

of the fore part, shown in various photographs, does not accord very well with the obtusely rounded head and shoulders of the Grampus, while the tail seems broader. To my mind the suggestion of one observer that it was probably a large Dolphin of an allied genus seems more probable, though, as Pelorus Jack was last reported in 1916 according to Hutton and Drummond, and no remains were discovered, its identity must unfortunately remain a mystery.

In recording the first occurrence of the Grampus in Australia Zietz (*loc. cit.*) wrote, under the heading *Grampus griseus*: "A skeleton of a Grampus, eleven feet long, was found on the beach between Glenelg and Brighton, the skull of which is in the Museum. It probably belongs to the above-named species, the only one in the genus, which is recorded from the North Sea to Capetown." It may be noted that, when recording the South Australian occurrence, Zietz was apparently unaware of the New Zealand record.

True stressed the danger of basing specific distinction upon crania alone, owing to the very great individual variation exhibited by the Cape Cod series of the Grampus. Variation in the dentition was also misleading to early workers; the number of teeth is usually quoted as being from three to seven on the one side, but the Brest specimen had but two on each side according to Cuvier's description.

It is noteworthy, regarding this brief review and the importance of the following records, that the 1922 'Guide' to the Cetacea exhibited in the British Museum omits Australia and New Zealand from the range of the Grampus.

A Male and Female Grampus stranded near Sydney.

In view of the interest attaching to the third Australasian record of a Cetacean involved in so much discussion abroad, it was deemed advisable to publish this preliminary account, leaving a critical review of the material till later.

The skull of the female has been cleared for inspection, and comparison of its dimensions with those listed by True suggest that the rostrum is relatively longer, particularly regarding the measurement from its tip to the end of the pterygoid crest. The pterygoid appears to be longer and differently shaped to that of the specimen figured in the 'Atlas' (pl. liv. fig. 7 a), differing in the greater extent of the lateral emarginations and in the production of the apex posteriorly to a more acute point; it is also heavily perforated, unlike the figure. This marked perforation, however, is in accordance with the pterygoid of the skull figured as *G. griseus* in the 'Atlas' (pl. lxiv. fig. 4 a), but again the shape differs considerably, lacking the even convexity of the inner margin shown in the figure, in which the apex of the angle is opposite the posterior fourth as in the Manly specimen. The teeth are apparently larger than in the South African specimen, the antero-posterior diameter of the smallest being 10.5 mm. and the largest 14 mm., as opposed to 0.76 cm. given by True for the "Diameter of mandibular teeth" in two specimens of "*richardsoni*."

A striking external feature was a very marked subtriangular groove or concavity in the front of the head which is not shown in figures of the animal, and, apparently, has only previously been noted by Flower, who described the anterior surface of the head as "somewhat hollowed in the middle line."

Specimen a.—Adult female; total length, to caudal notch, 9 ft. 10 in.; mandibular teeth 3—4; stranded on the ocean beach at Manly, Sydney, N.S.W., on the 28th February, 1927. Skeleton, registered no. S. 1776.

Colour.—The following notes were taken from the fresh specimen:—Pectorals, dorsal, and caudal black. Back and sides uniform black to a level with the

anterior bases of the pectorals, thence anteriorly there is a greyish tinge which tends to form a faint triangular mark on each side of the head, and is continued around behind the blowhole in a narrow line. The apex of the snout above and below shows the dark coloration, but the sides of the mouth to the top of the head and the under surface of the jaws are so closely striated with white lines as to suggest large white areas, though obviously the lines are due to injuries inflicted by the living prey. From the chin to the front of the pectoral fins the under surface is mottled with dirty white, thence being black to a level with the anterior origin of the dorsal fin, the remainder of the under surface posteriorly being of a dirty white tinged with the black of the upper surface. The lighter areas of the ventral surface are so restricted, however, that both specimens might be generally described as almost entirely black.

The specimen was first seen by Mr. Harry Hay, a well-known member of the Manly Life-saving Club, who was in the shark-tower at noon, and observed what appeared to be a Dolphin being attacked by Sharks, which seemed to be winning the battle; leaping at times about 4 feet from the water, the victim finally became stranded in a corner near the rocks at South Steyne, Manly, where it was secured by Mr. Hay and fellow surf-club members.

Subsequently purchased by the Trustees, the specimen is represented in the Australian Museum by a complete skeleton and coloured cast. Apparently the animal was sickly, or weakened by an untoward shortage of food, as the sole contents of the stomach was one cuttlefish beak; it is possible, however, that the excitement of the prolonged attack had caused it to discard the contents, as observed in other Cetaceans.

Specimen b.—Adult male; total length, to caudal notch, 9 ft. 7½ in.; mandibular teeth 4—4; stranded on Dee Why Beach, a few miles north of Manly, on the 18th February, 1929.

Examination of the second specimen, of which only the skull could be retained, proved it to be a male Grampus exhibiting no striking differences from the female, and being also of the same almost universally black coloration. The stomach-contents was negligible. Driven ashore by Sharks, the specimen was captured by members of the Dee Why Surf-Club, who presented the head to the Australian Museum; bleeding from its numerous wounds, it was retained in the water pending examination by Museum officials, when three large Whaler Sharks came within 10 feet of the shore and savagely snapped pieces from the animal.

General Conclusions and Acknowledgments.

The circumstances would suggest that both animals were weakened by sickness or prolonged attack during a regular migration southward around Australia or across to New Zealand, but it is not definite that this is so. The occurrence of the second specimen, of opposite sex, two years later in the same fortnight in February, however, certainly implies a use of the warm current then prevailing in an annual migratory movement. There is, indeed, a distinct possibility that the migrations of forms are more restricted than True's conception of the genus would admit, and that, while appreciating his remarks on the striking variation displayed by the Cape Cod series, diagnostic differences may ultimately separate specimens from distant regions. These comments should not be taken as a reversion to the extreme splitting and limited conception of range adopted by Gray, or as necessarily adopting Trouessart's acceptance ('Catalogue,' Supplement, 1904) of *southernianus*, *richardsoni*, *sakamata*, and *steurni* as definite subspecies, though to a degree such may be supported by the occurrence of several allied species of Dolphin in local seas.

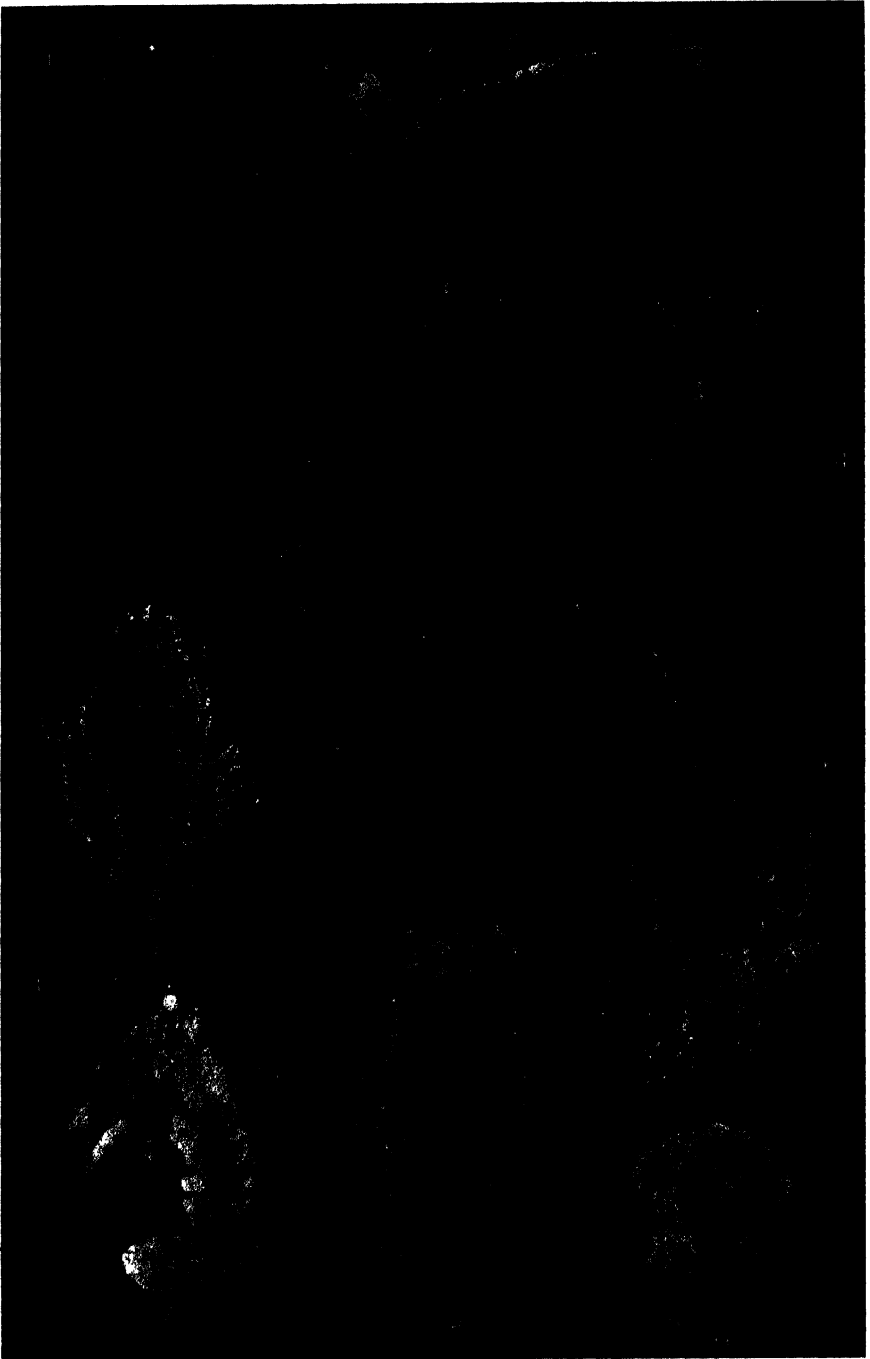
Whatever may be the solution of the above, there seems little doubt that the reputedly rare Grampus is actually quite plentiful over an enormous range, but is probably a form seldom coming close inshore save when ill or subjected to concerted attack.

At my request Mr. H. H. Finlayson, Hon. Associate in Mammalia to the South Australian Museum, kindly undertook a search for the specimen of Zietz's record, and informs me that it had never been registered, and apparently cannot now be traced. It would thus appear that the Sydney specimens provide the only verifiable record of the occurrence of the Grampus in Australia. Thanks are also due to Mr. G. C. Clutton, Museum Photographer and Preparator, for the photos of the animal and, with his assistant, Mr. J. Kingsley, for the preparation of skeletal material.

EXPLANATION OF THE PLATE.

Photos of the complete animal, and side and front views of the head, of the female *Grampus griseus* Cuvier, stranded at Sydney, 28th Feb., 1927.

- (1) Complete view of *Grampus griseus*. The light appearance of the sides is due to the characteristic sheen of the skin; the mark on the top of the dorsal fin was caused by a shark.
- (2) Side view of head. The ear is seen an inch behind, and slightly below, the eye-level, surrounded by a whitish mark. The scoring of cuttlefish beaks and hooks is shown, as well as marks left by barnacles and other parasites. It is clearly shown that the under surface, except where injured, is not remarkably lighter than the back or sides.
- (3) Front view of the head. The peculiar broad subtriangular groove in the front of the head is well shown, while the open mouth displays the heaviness of the teeth and their unsymmetrical arrangement.



NOTOCARIS TAPSCOTTI BROOM.

Photo J. Hewitt

32. On the *Pygocephalus*-like Crustacean of the South African Dwyka.

By R. BROOM, D.Sc., F.R.S., C.M.Z.S.

[Received January 5, 1931: Read March 17, 1931.]

(Plate I.)

A few years ago Mr. Sidney Tapscott discovered in the White Band of the Dwyka at Kimberley some small Crustaceans. These were sent by Miss Wilman, of the MacGregor Museum, Kimberley, to Mr. H. Woods of Cambridge for examination, and Mr. Woods wrote a small paper on the specimens, which he referred to as species of *Pygocephalus* *.

I examined the specimens shortly after they had been returned by Mr. Woods, and from their appearance I thought it probable that much better specimens might be obtained by further examination of the locality from which they had come. I therefore visited the spot with Mr. J. H. Power, who had collected some of the original specimens with Mr. Tapscott, and later by myself on two subsequent occasions. As a result of this further examination many very much better specimens have been obtained than any seen by Mr. Woods, and the specimens we now have reveal most of the characters of the form, and enable us to say a good deal more of the affinities.

While there is little doubt that Woods was right in placing the species near to the European Carboniferous *Pygocephalus*, it is certainly specifically distinct, and I think it is entitled to be placed in a distinct genus.

All the known specimens of *Pygocephalus* indicate that the chitinous exoskeleton is moderately thick.

In the South African form the exoskeleton is so extremely thin that it can be crushed either from above downwards or laterally with little or no breaking. Large specimens are crushed as thin as the tenth of a millimetre, and small specimens are apparently less than a fiftieth of a millimetre in thickness; and notwithstanding this extreme degree of flattening it is surprising how much of the structure is satisfactorily revealed.

The carapace is a thin, curved, oval structure which, as in the higher crustaceans, covers the thoracic region; but, as in the Mysidacea, it is only attached to the anterior two or possibly three segments. In fig. 2 (Pl. I.) we have a reproduction of a specimen which is laterally crushed, and the degree of attachment of the carapace shown.

There is no rostrum. As in typical higher crustaceans there are six abdominal segments and a well-developed telson. Most of the appendages can be seen.

The eyes are relatively small and on the end of a fairly long peduncle.

The antennules are biramous and the antennæ long and well developed, and with, as in typical higher crustaceans, a large scale.

Something of the structure of the mouth-parts can be seen in a number of specimens.

Fig. 3 (Pl. I.) shows the head-appendages, mouth-parts, and many thoracic appendages of a somewhat crushed specimen, twice natural size. Near the basis of the antennæ are seen the two small ocular peduncles. The axes of the

* "Note on *Pygocephalus* from the Upper Dwyka Shales of Kimberley." Trans. Geol. Soc. S. Africa (Johannesburg), xxv. 1922, pp. 41-42, pl. vi.

peduncles lead to a small transverse light patch in the middle line. This appears to be the labrum. A short distance behind it are what I regard as the two mandibles. These are well seen also in fig. 6 (Pl. I.), and less clearly in fig. 8 (Pl. I.).

The maxillulæ and maxillæ are apparently small and not clearly seen in any of the specimens.

The first thoracic appendage is well developed, is apparently a maxilliped with a very large basipodite and a well-developed endopodite, as is seen in fig. 3 (Pl. I.). As in the other thoracic appendages there is also a long-jointed exopodite.

The other seven thoracic appendages are all typically Mysid in structure, but seem to be more nearly allied to those of *Gnathophausia* than to those of *Mysis*. The exopodite is long and pointed, with very numerous joints. The endopodite, so far as can be seen, is essentially similar to that of *Gnathophausia*, as can be seen in fig. 8 (Pl. I.). No setæ have been observed in any of the specimens, but of course they may have been present and not preserved.

As in the Lophogastridæ, gills are present in connection with the posterior seven thoracic appendages. As can be seen in fig. 2 (Pl. I.) one long branch passes up by the side of the thorax. Short sternal branches pass inwards from the bases of the appendages. These are well seen in figs. 5 & 8 (Pl. I.), and less satisfactorily in figs. 4 & 6 (Pl. I.).

The abdominal appendages have only been seen in one specimen, and that a half-grown one. They appear to be somewhat similar to those in *Gnathophausia*, but relatively smaller.

In the very large majority of the specimens the abdomen is folded round, so that the telson lies under the back part of the sternum. In figs. 6 & 8 it can be clearly seen. In two specimens the telson and posterior abdominal region have apparently been detached and are nearly perfectly preserved. One of these is shown in fig. 9 (Pl. I.). The telson is triangular and pointed, as it is in *Pygocephalus*. The uropods are broad and decapod-like. There is a large protopodite, which has a large exopodite and a small endopodite. The exopodite has a short spine-like outer portion and a broad fan-like inner. The endopodite is less than half the size of the exopodite. Just possibly it bears a statocyst.

The sternum is well preserved in a large number of specimens; being extremely thin it differs considerably from that in *Pygocephalus*. It has been well figured by Woods.

In one specimen the oostegites are beautifully seen; this is shown in fig. 7 (Pl. I.). The specimen is much crushed and the carapace pushed over to one side. The oostegites are very similar to those of *Pygocephalus*, but are rounder than in *P. cooperi*. As in *Pygocephalus* and the Lophogastridæ there appear to be seven pairs.

This Dwyka crustacean may be regarded as a primitive freshwater Mysid, more nearly allied to the Lophogastridæ than to the Mysidæ, and retaining more of the primitive Caridoid facies than any of the surviving Mysids.

I propose calling it *Notocaris tapscotti*.

Apart from the zoological interest of the specimens, the additional light is of considerable importance geologically. There has been much difference of opinion concerning the age of the Dwyka. As apparently contemporaneous glacial beds are found in South Africa, South America, India, and Australia, if we could determine the age of the South African beds we could correlate the Gondwanaland formations with those of Europe and North America.

Formerly the Dwyka was considered to be of Lower Permian age. Within recent years, however, there have been many geologists who have maintained that it is of Upper Carboniferous age. Schuchert, of Yale, has recently argued that it cannot be older than Middle Permian.

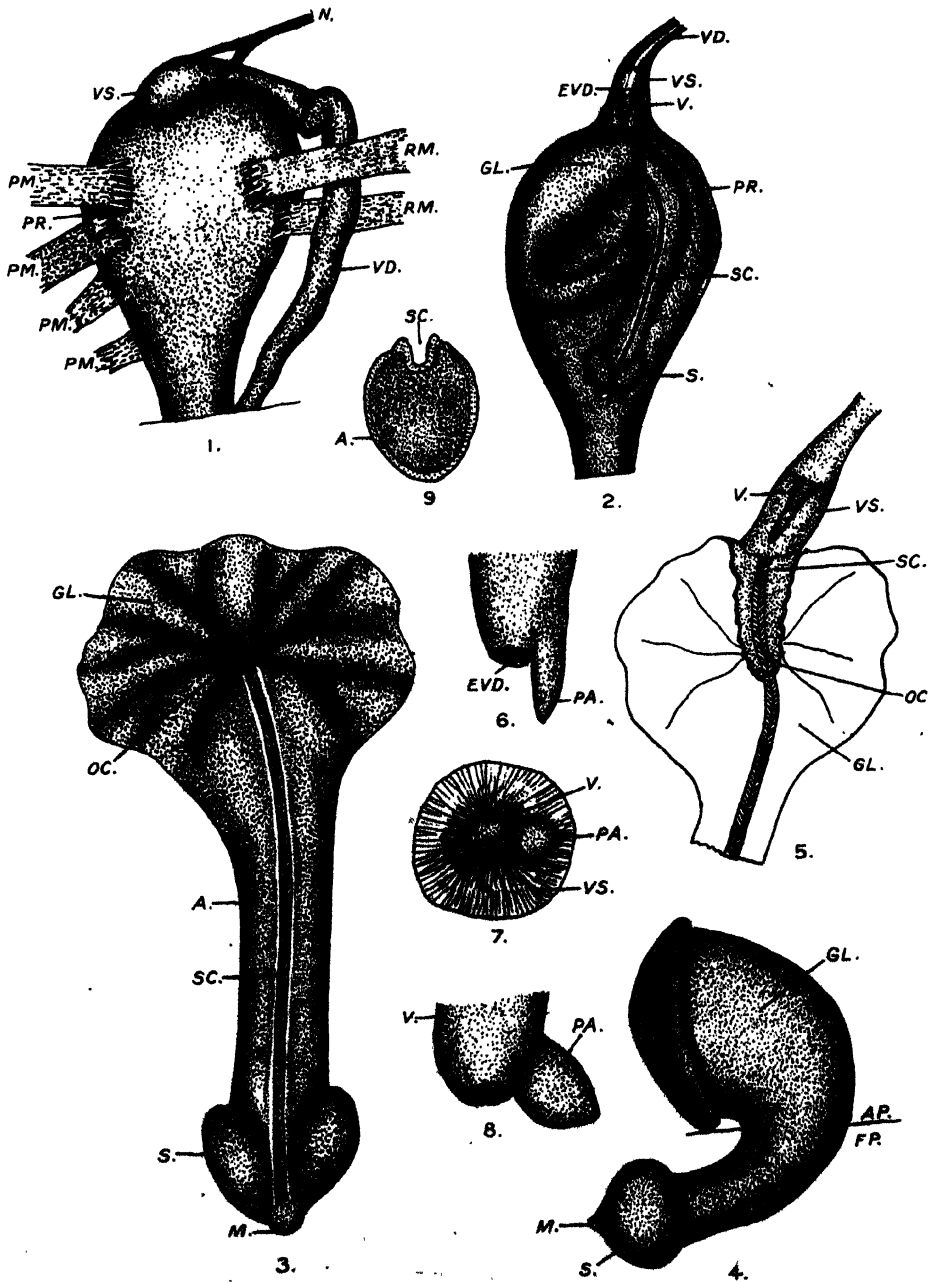
Those who hold that the Dwyka is Carboniferous consider that the occurrence in it of the Carboniferous *Pygocephalus* strongly supports their view. The further evidence of the structure of the Dwyka crustacean shows that while it belongs to the same family as the Carboniferous *Pygocephalus* it is not sufficiently near to it to support the view that the Dwyka is Carboniferous.

Whatever other evidence may be brought forward to determine the age of the Dwyka, it seems to me that little weight can be placed on the occurrence of this *Pygocephalus*-like crustacean.

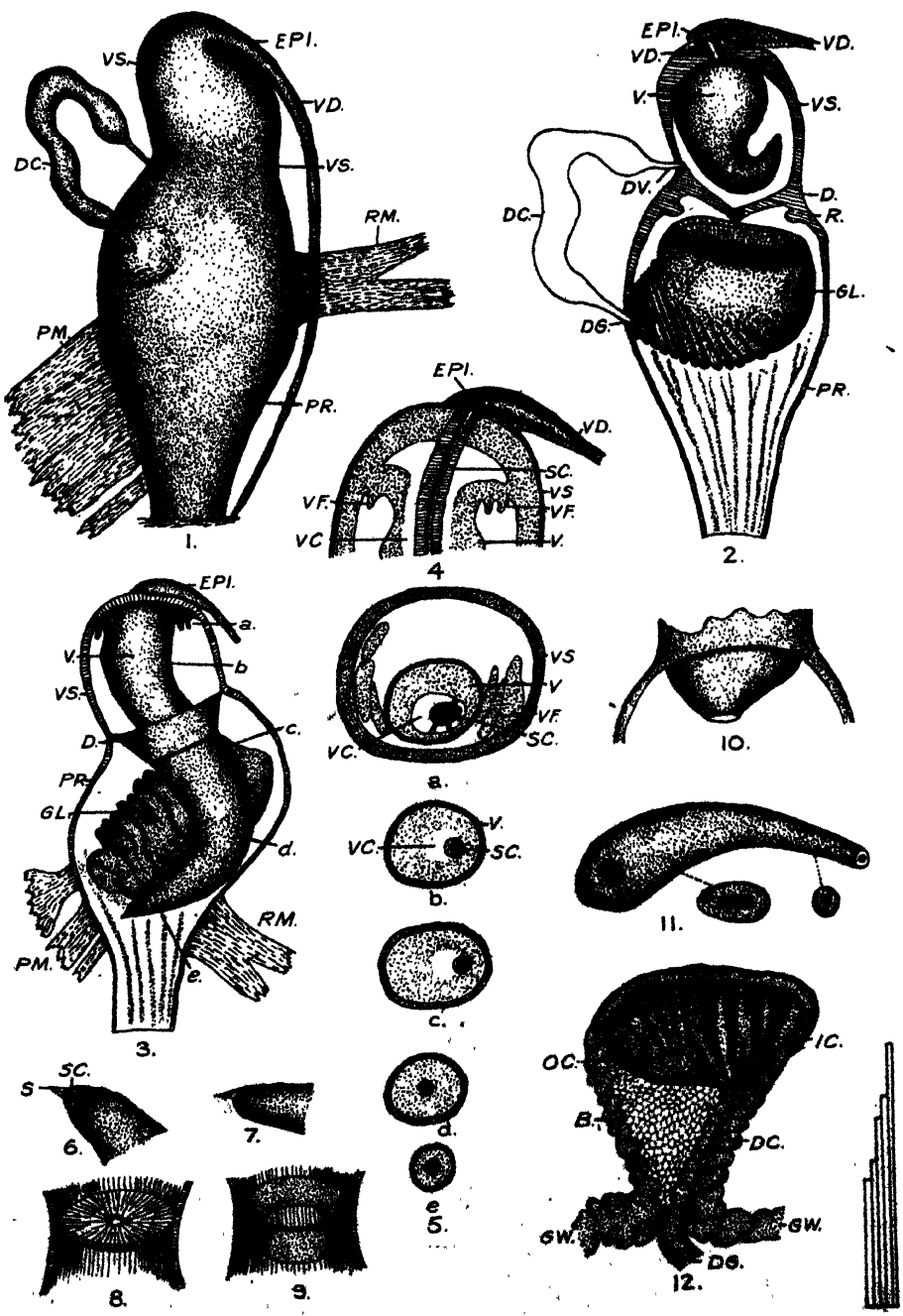
I must express my indebtedness to Miss M. Wilman, of the Kimberley Museum, not only for the opportunity of examining the Museum specimens, but also for the information that enabled me to collect a large number of others, and to Mr. J. Hewitt, of the Grahamstown Museum, for the excellent photographs he has made of the principal specimens; he has succeeded much better than I had thought possible in the differentiation of the fossil from the somewhat similarly coloured matrix, with the result that the photographs are in some instances more satisfactory than the actual specimens.

EXPLANATION OF THE PLATE.

- Fig. 1. Upper side of *Notocaris tapscottii*. About natural size.
 2. Side view of *Notocaris tapscottii*. About natural size.
 3. Underside of *Notocaris tapscottii*. Considerably crushed. Twice natural size.
 4. Underside of *Notocaris tapscottii*. About natural size.
 5. " " " " "
 6. " " " " "
 7. Underside of female *Notocaris tapscottii*, showing oostegites. About natural size.
 8. Underside of *Notocaris tapscottii*. About natural size.
 9. Posterior part of *Notocaris tapscottii*, showing telson and uropods. About natural size.

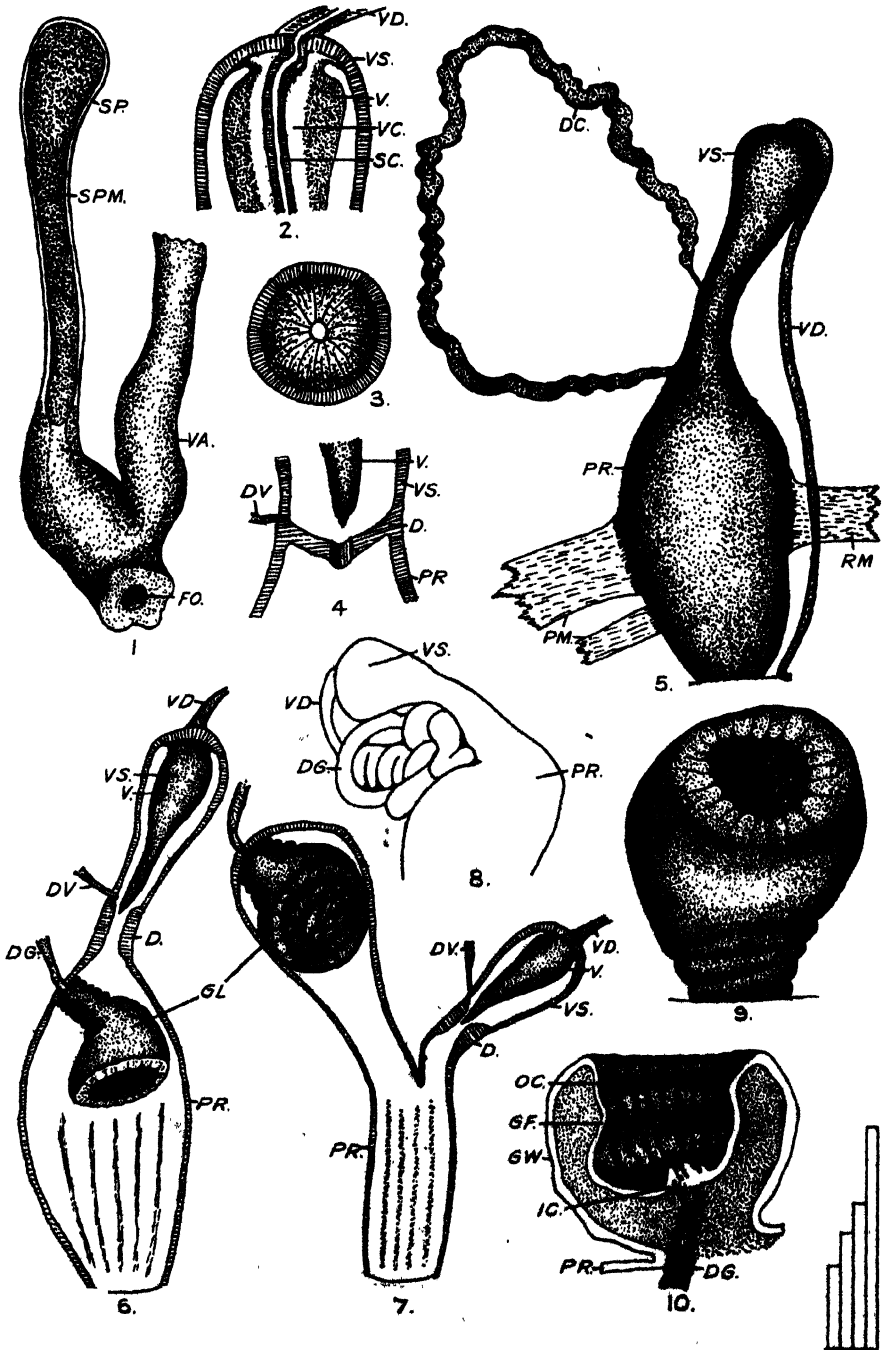


Mar. Biol. Soc. & Durham, 1931, London.



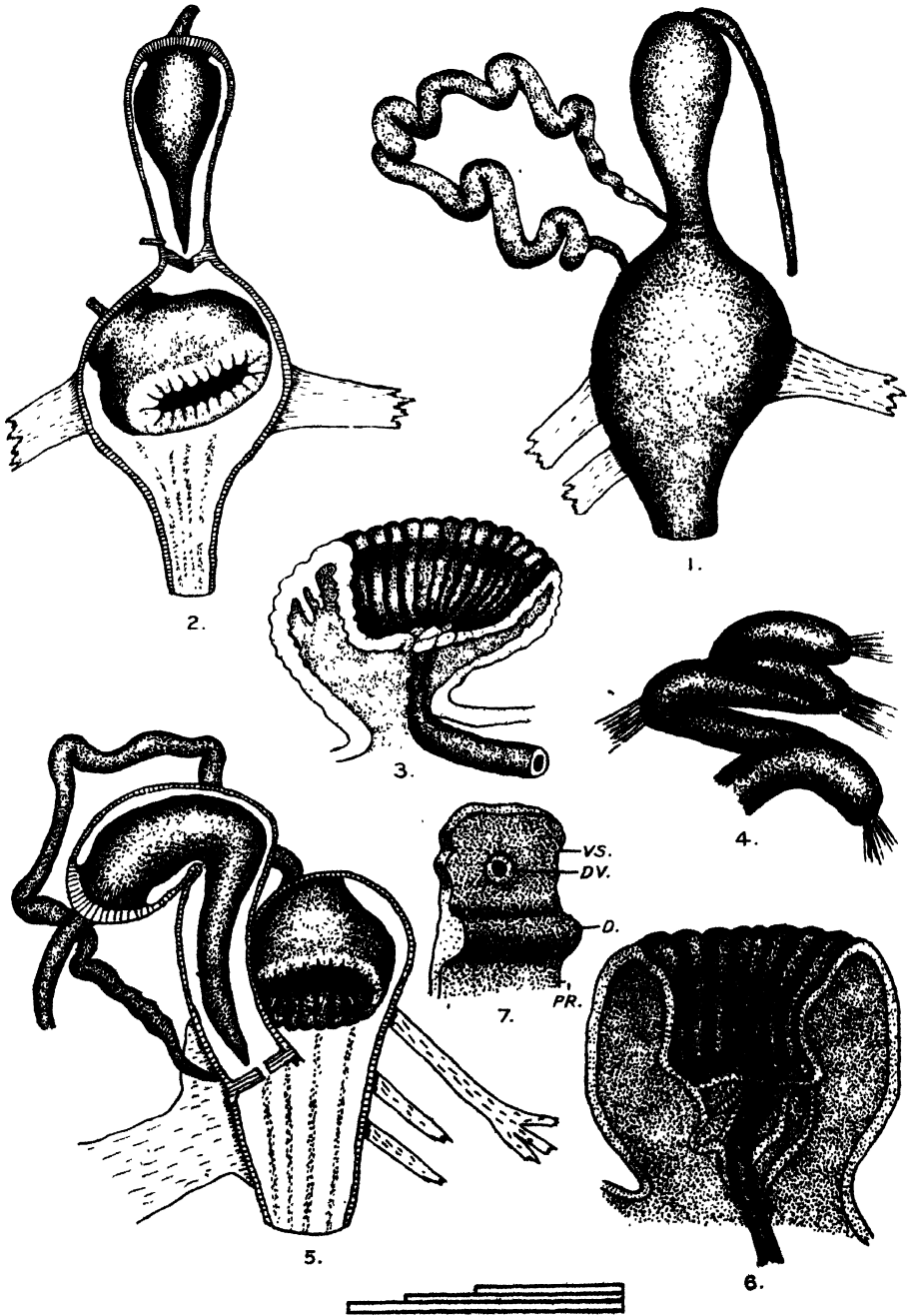
John Bain & Co., 12, Northampton, 17, London

LARGE PLANDROID WHALES OF EUROPE AND AMERICA

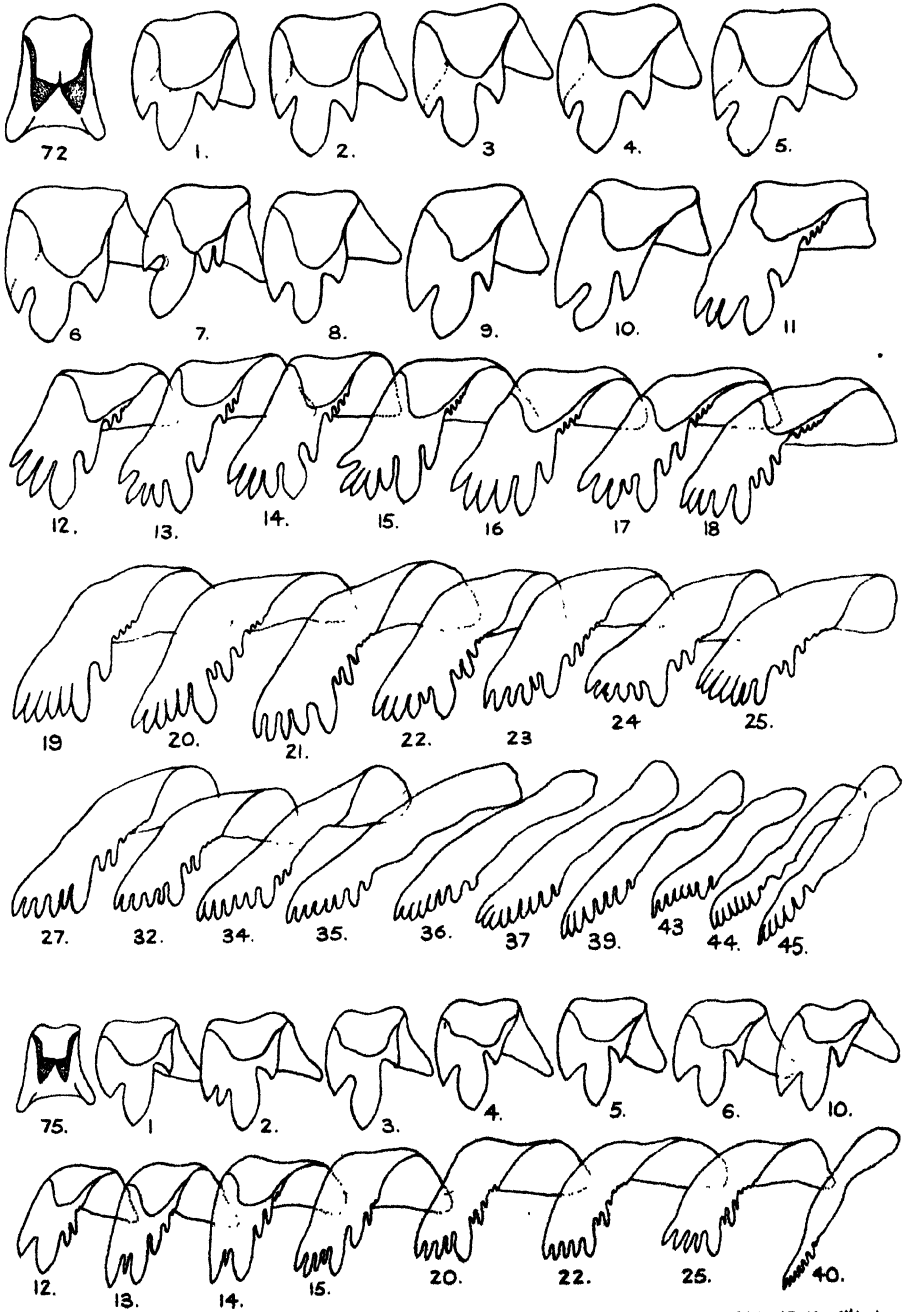


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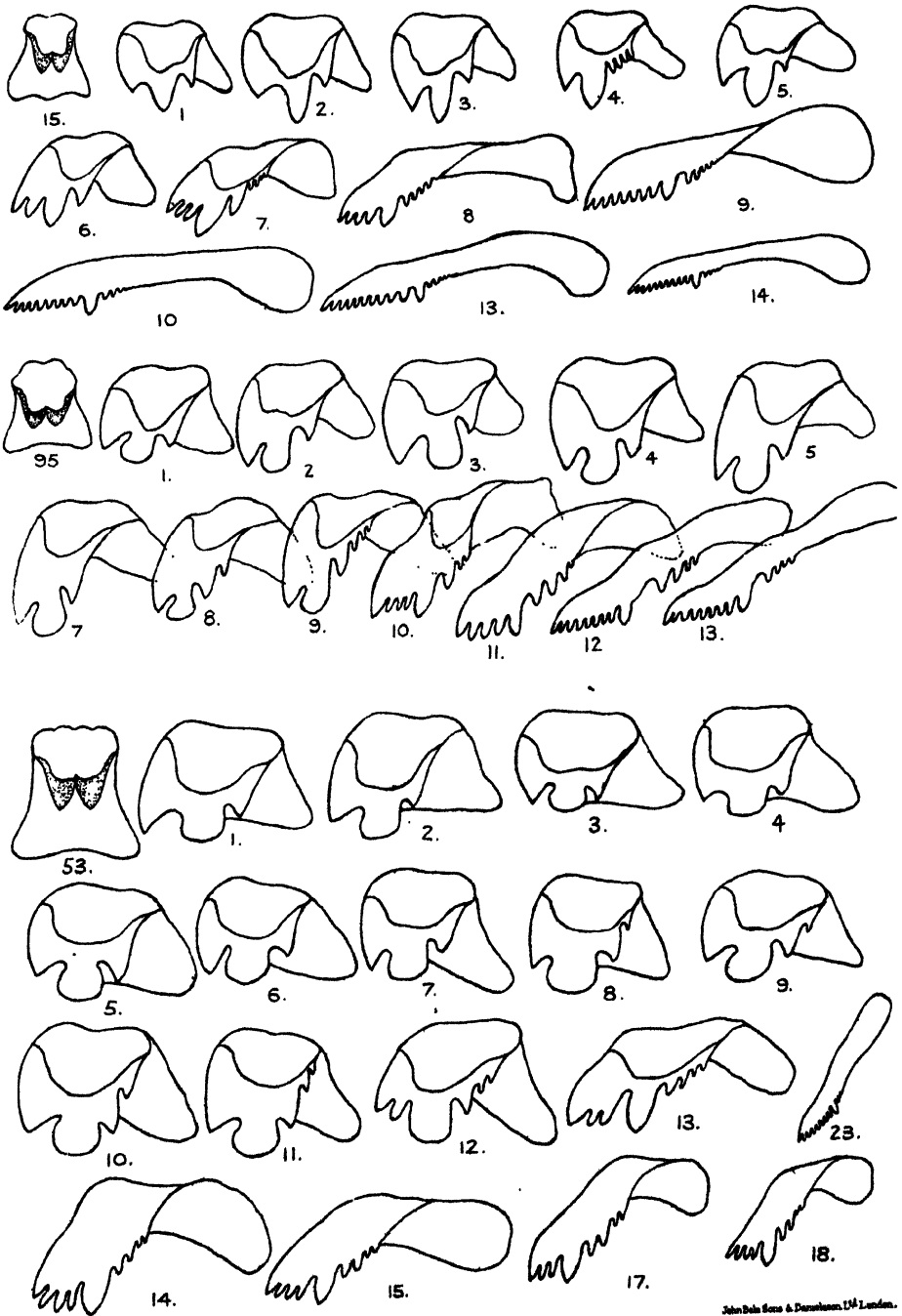
LARGE PLANORBROID SNAILS OF EUROPE AND AMERICA.



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John Bain Scott & Bartholomew, Ltd. London.



John Bell Sons & Dartmouth, Ltd. London.

LARGE PLANORBROID SNAILS OF EUROPE AND AMERICA.

33. The Classification of the Large Planorboid Snails of Europe and America. By FRANK COLLINS BAKER, B.Sc., C.M.Z.S.

(Contribution from the Museum of Natural History, University of Illinois, Urbana, Illinois, U.S.A., No. 59.)

[Received October 31, 1930: Read February 3, 1931.]

(Plates I.–VI.)

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1. INTRODUCTION.

The large wheel-snails or orb-snails generally known as *Planorbis* are abundant and widely distributed throughout the world. Scarcely a body of fresh water can be found that does not contain one or more species of these interesting mollusks. Although the shells of the freshwater pulmonates (Pulmonata Basommatophora) have been studied for many years and several group names have been proposed for major variations of shell structure, comparatively little attention has been given to the internal organization of the animals of this large group, excepting for a few species. During this period the land pulmonates (Pulmonata Stylommatophora) have undergone the most drastic revisions, resulting in the characterization of many genera and other groupings, all based on peculiarities of the anatomy of the animal. Pilsbry (1894), in the 'Guide to the Study of Helices,' placed the classification of the helices on a solid foundation. Later investigation by Pilsbry, H. B. Baker, and others have

added greatly to the knowledge of the structural relationships of the species of the American fauna.

But no such extensive studies have been made of the animals of the freshwater pulmonates. Several European authors, Baudelot, Buchner, Moquin-Tandon, and others, have made detailed studies of a few of the common species, but this has not been extended to cover all forms of a genus or family. Some years ago (1911) the writer published a monograph of the Lymnæidæ of North and Middle America, introducing a classification based largely on characteristics of genitalia and radula. Later (1928) the Basommatophora of the north central part of the United States were monographed, the classification being based on the same characteristics of the animal. Isolated contributions on certain species have been made by a number of students, both European and American. It is proposed in this paper to discuss the general features of the genitalia and radulæ of the large American Planorbis, comparing these with the groups of Europe and elsewhere.

2. ACKNOWLEDGMENTS.

In the preparation of this paper the author has been assisted by a number of people who have contributed alcoholic and living material for anatomical study or have assisted in other ways in the study:

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Dr. B. Prashad, of the Indian Museum, Calcutta, India, has furnished data on the genus *Indoplanorbis*, and has given citations to literature relating to this group.

To Dr. Van Cleave the author is especially indebted for a careful reading of the manuscript and for suggestions brought out thereby in relation to nomenclature and related subjects.

3. GENITAL ORGANS OF THE PLANORBIDÆ AND THEIR SIGNIFICANCE IN CLASSIFICATION.

The genital system of the members of this family has been figured by several authors, notably that of *Planorbis corneus* and *Planorbis vortex* by Buchner (1891), *Planorbis corneus* by Bordelot (1863), and the same species by Lacaze-Duthiers (1872). Examples of the American species included in the genera *Helisoma*, *Planorbula*, and *Gyraulus* have been described and figured by Baker (1928). While the general form of the genital system is well known, the details of structure of the male organ, in which the greatest specific and generic variation occurs, is comparatively little known and understood. These variations afford good characters for the discrimination of genera based on the presence or absence of certain organs or the variation in form of certain parts of the male complex.

Students of the land pulmonates and of the freshwater pulmonates have differed somewhat in the nomenclature used for the parts of the genitalia of the two groups. It would appear to be desirable that, as far as possible,

a uniform nomenclature be adopted, and this has been done in the present paper. The terms applied to the principal parts of the entire hermaphrodite system have been defined and figured by several students, notably Buchner and Simroth, and for the American species by the writer in the 'Monograph of Wisconsin Fresh Water Mollusca' (Planorbidae, pp. 311-313) and in the Lymnaeidae Monograph (1911, pp. 188-190). These organs are, in general, very uniform, the variation being almost exclusively confined to the male generative organ, in the Planorbidae at least, and this may be termed the penial complex. The different organs of this complex may be defined as follows:—

Epiphallus (E.P.I.).—This name has been applied to a small enlargement of the vas deferens as it enters the penial complex in land snails, and it may be applied to a similar enlargement in the vas deferens of the Planorbidae, although it is not as conspicuous as in the land species (Pl. II. figs. 1, 2).

Vergic Sac (V.S.).—The distal part of the penial complex is always distinguishable from the proximal part and is separated from the latter by a more or less distinct constriction, the *diaphragm*. Also known as *penis-sheath* and *hyperphallus* (Pl. II. fig. 1).

Preputial Sac (P.R.).—The proximal end of the penial complex, also known as *preputium*.

Verge (V.).—The male intromittent organ should be called the verge, since the whole complex is called the penis in land snails, and the term is also in general use for the marine and freshwater snails of the order Ctenobranchiata. The verge contains a longitudinal cavity, the *vas deferens* passing on one side of this space (Pl. II. figs. 2-5).

Spermatophore Gland (G.L.).—Within the preputial sac there is a large gland in which the spermatophores are formed. In some species a duct leaves the base of this gland and passes to the vergic sac just above the diaphragm which separates the vergic sac from the preputial sac. The duct is coiled on the outside of the upper part of the preputial sac (D.V, D.G, D.C, D). See the figures on Pl. II.

Sperm Canal (S.C.).—This may be a channel on the surface of the sarcobelar appendage (Pl. I. fig. 3) or a closed tube within the verge connecting directly with the vas deferens (Pl. II. fig. 4).

Sarcobelum (S.).—This may be a large fleshy organ, as in *Planorbis corneus* (Pl. I. fig. 3, A), or a small stylet or stylet-like termination of the verge (Pl. II. figs. 6, 7). Its purpose is to stimulate the animals to sexual desire. This organ has been called a *stimulus* by von Ihering, but this term is objectionable because it describes the act of stimulating. Taylor's sarcobelum is preferable.

There are one or two retractor muscles attached to the preputial sac and entering the columellar muscle, and one or a series of retractor muscles entering the muscles of the dorsal part of the head. The duct of the spermatophore gland is attached to the preputial sac by several muscles (Pl. IV. fig. 4). The characteristics of the penial complex in the different groups will be noted under the description of each group.

4. ANATOMICAL CHARACTERISTICS OF *PLANORBIS CORNEUS* (LINN.).

Genitalia. (Pl. I.)

The penial complex of *Planorbis corneus* is enclosed in a large, pyriform, preputial sac (P.R.). The vergic sac (V.S) is very small and in the natural position lies across the summit of the preputial sac. The vas deferens is of large diameter relatively. There are two retractor muscles (R.M) attached to the left side of the preputial sac, their terminations entering the columellar

muscle. There is a series of retractor muscles, usually four in number, attached to the right side of the preputial sac and entering the muscular integument of the head (*P.M.*). There are no muscles attached to the vergic sac (penis-sheath) as figured by Buchner (1891, pl. vi. fig. 1) and copied by Simroth (1912, p. 502). A number of specimens have been examined to ascertain this fact. A large nerve proceeds from the left cerebral ganglion and passes to the posterior side of the preputial sac, where it divides into several branches innervating the entire penial complex. In several specimens this nerve bifurcated at the distal end of the complex, the branches entering the preputial sac near the vergic sac (Pl. I. fig. 1, *N*).

Internally (fig. 2) the structure of the penial complex is different from any published figure observed by the writer. The vergic sac (*V.S*) is very small and is attached to the distal end of the preputial sac at about the centre. Within the preputial sac there is a large fleshy organ consisting of two parts, a bilobed organ, the spermatophore gland (*G.L*), and a long cylindrical organ with a bulbous termination and with a narrow rather deep channel on the upper surface extending from the centre of the gland to near the end of the elongated organ. This organ terminates in a small mamma-like projection (figs. 2, 3, 4, *A, S.C, M*). The channel enters an opening in the centre of the gland, where it continues to the opening of the vergic sac (fig. 5, *S.C, O.C*). The verge (*V*) is a very small organ completely filling the vergic sac. The opening of the vas deferens (or sperm-canal) is at the termination of the verge and in the centre, but there is a fleshy projection or appendage that extends beyond this opening, giving the impression that the exit is at the side of the verge. During the breeding period this projection is extended forward in a line with the verge (fig. 6), but when at rest it is more or less folded back (figs. 7, 8). Cross-sections of the cylindrical appendage show it to be composed of muscular tissue, the groove or channel being deeply incised in the upper surface (fig. 9). The bulbous termination of this appendage is an excitatory organ or sarcobelum (fig. 3, *S, M*). A portion of the appendage is attached to the preputial sac; but the terminal portion is free and capable of considerable extension (fig. 4, *A.P, F.P*).

The figures on Pl. I. differ widely from those previously published. Buchner's figure (1891, pl. vi. fig. 1) shows a large vergic sac with the verge or penis within this cavity and not in the preputial sac, and the small verge is not shown, the large fleshy appendage being indicated as though extending directly from the vas deferens. The large gland is not shown. A dozen specimens of *Planorbis corneus* have been dissected, but nothing approaching Buchner's figure has been observed. Buchner's type I. (*Planorbis corneus*) has been copied by Simroth (1912, p. 502) and by the writer (1928, p. 308). The cylindrical appendage and gland have been correctly figured by Baudelot (1863, pl. iv.), but the appendage is called the penis (verge). The true verge is not shown. Taylor (1900, p. 366) figures the terminal bulbous portion of the appendage (after Moquin-Tandon, 1855), calling it the vibratile stimulatory appendage, which it obviously is. This appendage evidently performs the function of a verge. No previous author apparently has described the true verge as shown on Pl. I.

5. PHYSIOLOGY OF THE PENIAL COMPLEX IN *PLANORBIS CORNEUS*.

The function of these organs in *Planorbis corneus* is of great interest. The elongated appendage performs the duty of a true verge or penis and is the intromittent organ in this species. The terminal bulbous portion is an excitory organ, a sarcobelum. The sarcobelum is freely extended from the

opening during the breeding period. Spermatozoa are discharged from the small verge in the vergic sac into the channel passing through the spermatophore gland (Pl. I. fig. 5, *S.C.*). This gland secretes the wall of the spermatophore within which the spermatozoa are encased, and the combined product passes down the channel in the appendage and into the female opening and is stored in the spermatheca of the snail playing the part of the female to await the descent of the ova. The small projection at the end of the verge (fig. 6) probably aids in directing the vasdeferens (*E.V.D.*) opening to the channel in the gland (fig. 5, *V, S.C.*). As far as known this method of transferring the sperm has not been previously noted.

6. THE RADULA OF *PLANORBIS CORNEUS*. (Pl. V.)

In typical *Planorbis* the central tooth of the radula is always bicuspid; the laterals are always tricuspid, usually ten in number, and the marginals are more or less comb-like. There may or may not be several intermediate teeth between the lateral and marginal series. The entocone and the ectocone * become modified beyond the tenth tooth, the entocone splitting into several small cusps, and the ectocone into two or more cusps. The outer marginals, about ten in number, are simply comb-like at the distal end.

Taylor (1900, p. 270) figures the laterals of *Planorbis corneus* as bicuspid, and in this he is followed by Simroth (1912, p. 316). Taylor also figures but 33 teeth in a row, while in all membranes examined in the present study there have been 45. The specimens examined were sent from Germany by Dr. F. Haas. Upwards of a dozen specimens have been examined without any variation being noted from the number of teeth or the tricuspid character of the lateral teeth. Of course the number of teeth in a row may differentiate species within the *Planorbis* group, and those of Germany are possibly a different variety from the specimens figured by Taylor. The number of rows varied from 170 to 210 in large specimens from Germany, and were as high as 218 in aquarium specimens from an unknown source. The radula of the latter species differed notably in size from the radula of the German species. This is well shown on Pl. V., where the seventy-second row of a German specimen is figured and the seventy-fifth row of an aquarium specimen is figured for comparison, all camera lucida drawings to the same scale. The German specimens have uniformly larger teeth on all parts of the radula membrane, as shown in the table below, in which the central teeth of a complete membrane are measured for comparison.

| German specimen. | | Aquarium specimen. | |
|------------------|-----------------|--------------------|-----------------|
| Rows. | Size in μ . | Rows. | Size in μ . |
| 1-6 | 15.5 | 1-86 | 11 |
| 7-50 | 17 | 87-188 | 10 |
| 51-166 | 17 | 189-210 | 8.5 |
| 167-210 | 14 | 221-218 | 8 |

It will be observed that the size of the teeth decreases toward the lower portion of the membrane. This has been found true of all radulae examined, both European and American, and the difference in size appears to represent a universal law of variation. The first few teeth may be somewhat smaller, as shown in the German specimen.

* For the use of these terms in the Basommatophora, see Baker, 1928, i. p. 192.

7. ANATOMICAL CHARACTERISTICS OF *HELISOMA ANTROSUM* (CONRAD).

The penial complex of a large American planorbe is well illustrated by *Helisoma antrosom* (Conrad) (= *Planorbis bicarinatus* (Say)), shown on Pl. II. The preputial sac (*P.R*) is large and elongate-pyriform in shape; the vergic sac is also large and bulbous (*V.S*) and is separated from the preputial sac by a slight constriction. The vas deferens (*V.D*) enters the summit of the vergic sac, in the natural position being bent over the side of this sac (fig. 1). A slight enlargement of the vas deferens as it enters the vergic sac may be considered an epiphallus (*EPI*), this enlargement dilating internally (fig. 11). There is usually one large retractor muscle attached to the distal part of the preputial sac and entering the columellar muscle, but this may be broken into two muscles of equal or of unequal size (fig. 1, *R.M*). There is also a group of retractor muscles attached to the right side of the preputial sac, somewhat below the left retractor muscle, and entering the muscular integument of the fore part of the head. A short duct of large diameter—the duct of the spermatophore gland—lies on the distal part of the preputial sac between this sac and the vergic sac. In the natural position this duct is rather closely attached to the preputial sac by fine integumental muscles. In fig. 1 (*D.C*) it is shown as separated from the sac and spread out. A nerve from the left cerebral ganglion innervates the vergic sac and the preputial sac.

Internally (fig. 2) the preputial sac is seen to be completely separated from the vergic sac by a strong muscular diaphragm (*D*). In some specimens there is a muscular ring just below the diaphragm (*R*). The large fleshy verge (*V*) almost fills the vergic sac and is bent upon itself when the organ is at rest. The vergic sac has thick muscular walls. Within the preputial sac there is a large glandular body, the spermatophore gland (*G.L*), the free end of which forms a deep cup-shaped depression with folded walls. From the proximal end, attached to the body-wall of the preputial sac, there extends a short tube or duct which enters the vergic sac just above the diaphragm. This duct is very wide throughout its length, diminishing only where it enters the vergic sac and the preputial sac (*D.C*, *D.V*, *D.G*). The walls of the upper part of the preputial sac are thick and muscular, but the walls of the lower part are usually very thin. Internally (fig. 2, *PR*) the walls are more or less folded vertically.

The verge (*V*) is a large elongate-pyriform or cylindrical body capable of great extension by blood pressure. The vas deferens or sperm-canal passes through the verge a little to one side of the centre and borders a large vertical space or cavity which may be filled with fluid when the verge is extended from the vergic sac into the preputial cavity (figs. 4, 5, *a*). This feature is well shown in the sections under fig. 5, made at different places throughout the length of the verge. The epiphallus portion of the vas deferens lies over the opening of the sperm-canal in the vergic sac, the aperture through which the spermatozoa pass from the vas deferens being a short distance from the margin of the underside of the epiphallus (fig. 11; also fig. 2, *EPI*, *V.D*). The distal end of the verge is rather sharply pointed and at its termination there is a small triangular, transparent, or translucent appendage which performs the office of a sarcobelum, perhaps in a similar manner to the stylet in the genus *Gyraulus*. This small appendage extends beyond the sperm-canal opening, which is in the centre of the verge (figs. 6, 7).

The diaphragm between the preputial sac and the vergic sac varies in form with the condition of the sex organs. When the verge is fully withdrawn into the vergic sac and is in a perfectly quiescent state the diaphragm forms a more or less thin drum-like membrane across the constriction between the

two sacs, and the perforation in the centre is very small (fig. 2, *D*; fig. 8); but when the verge is in a more active state the diaphragm opens widely and becomes more or less dependent, permitting the verge to pass through it into the preputial cavity and thence to the external male opening behind the left tentacle (fig. 3, *D*; fig. 9). Frequently a specimen may be observed in which the diaphragm has become nearly closed but is still pendent within the preputial sac (fig. 10).

The spermatophore gland (*G.L.*) is an elongated muscular body filling a large portion of the space within the preputial sac. It forms a cup-shaped body capable of some extension. In the resting period it turns upward toward the vergic sac (fig. 2), but in many specimens it has been observed in a reverse position, the cup-like cavity turned toward the external opening of the male organ (Pl. IV. fig. 5). The walls of the gland are thick and muscular. When seen in section (Pl. II. fig. 12) the upper portion forms a large cup-shaped cavity which is divided into two parts, an inner cup (fig. 12, *I.C.*) in which there are several large vertical folds and an outer cup (fig. 12, *O.C.*) in which the folds are few and inconspicuous. In a specimen in which the cup portion had been completely turned inside out over the lower portion the outer cup walls were perfectly smooth without folds. The lower portion of the gland is solidly cellular, forming a reticulated pattern. The duct enters the lower portion of the gland and passes to the floor of the inner cup (fig. 12, *D.C.*). The external portion of the duct decreases in size as it enters the gland.

In other American species of *Helisoma*, as *Helisoma trivolvis* Say and *Helisoma campanulatum* Say (Pls. III., IV.), the genitalia depart rather widely from that described for *Helisoma antrosom*. The vergic sac may be long and pyriform in shape and separated from the preputial sac by a very narrow constriction. The duct of the spermatophore gland may be very much longer than that of *antrosom*—in fact twice as long as the vergic sac and the preputial sac combined. The vergic sac also may be either at the distal end of the preputial sac or it may be halfway to or quite near the external opening of the penial complex. In many species the spermatophore gland has but one large cavity at the upper end, the duct passing to the several folds on the bottom of this cup (Pl. IV. figs. 3, 6).

8. PHYSIOLOGY OF THE PENIAL COMPLEX OF *HELISOMA ANTROSOM*.

The function of the large gland in the preputial sac is apparently twofold. In many specimens examined it has been observed that the cup-like cavity of the gland was filled with spermatophores, which resemble parasitic worms, and may, indeed, have been so identified by some observers. These spermatophores are apparently secreted by the large outer cup in *Helisoma antrosom* and by the folds in the walls of the cup in some other species (*Helisoma trivolvis*, *Helisoma campanulatum*). The inner cup (*I.C.*) is usually free from spermatophores in *Helisoma antrosom*, and its function appears to provide a product which acts upon the diaphragm (*D*), causing it to retract for the passage of the verge (fig. 3, *D*, *V*). In the other species the folds in the bottom of the cup perform this function.

In all American species of *Helisoma* examined there is evidence of the twofold function of this gland, although the gland differs in the form of the cup in different species, as shown on Pls. II., III., and IV. In *Helisoma trivolvis*, *H. campanulatum*, and other species the whole cup may be closely packed with spermatophores awaiting the spermatozoa. The verge in the American group of planorboids is fully everted from the preputial sac, and acts both as a sarcobelum or stimulating organ and as a copulatory organ. The exact method of transfer of the spermatophore from the gland to the spermatozoa,

and of the joining of these two products, has not been observed by the writer. The spermatophore gland has frequently been observed in a reversed position, the open cup pointing toward the male opening in the neck of the animal (Pl. III. fig. 7, *G.L.*). The spermatophores may be discharged when the gland is in this position.

9. THE RADULA OF *HELISOMA*.

The radulae of the American Planorbis are like that of the European *Planorbis corneus* in having a bicuspid central tooth, tricuspid lateral teeth, and comb-like marginal teeth. There are differences in the form of the central tooth, especially in the length and shape of the cusps, in the shape and number of the lateral teeth, in the form of the marginal teeth, and in the number of teeth in a row. Apparently the American species may be grouped by the shape of the cusps of the lateral teeth, these being long and pointed in *Helisoma antrosom* and rounded and blunt in *Helisoma trivolvis* and *H. campanulatum* (Pl. VI. figs. 15, 95, 53). The size of the central tooth also varies, and this feature is often of value in distinguishing species and varieties. There is some variation in the size of the teeth on the same membrane, as already noted under *Planorbis corneus*, but this variation is uniform in most series of the same species. The variation in the central tooth of three American species of *Helisoma* is noted below for comparison.

| <i>H. antrosom</i> . | | <i>H. campanulatum</i> . | | <i>H. trivolvis</i> . | |
|----------------------|-----------------|--------------------------|-----------------|-----------------------|-----------------|
| Rows. | Size in μ . | Rows. | Size in μ . | Rows. | Size in μ . |
| 1-35..... | 14 | 1-94..... | 14 | 1-20..... | 18 |
| 36-150..... | 12 | 95-120..... | 13 | 21-158..... | 20 |
| | | | | 159-180..... | 17 |

10. CLASSIFICATION OF THE LARGE PLANORBID SNAILS OF EUROPE AND AMERICA.

From the data presented in the previous pages it is evident that there are great differences in the general character of the genitalia of the large species of mollusks referred to the genus *Planorbis*. The form of the penial complex in *Planorbis corneus* (Pl. I.) is notably different from the penial complex of all American species thus far examined (Pls. II., III., IV.). These characteristics are of generic importance, as was indicated by the writer in the Wisconsin Monograph (Baker, 1928, p. 310). The examination of the radula of *Planorbis corneus*, however, shows that the distinction based on a bicuspid condition of the lateral teeth was an error, due to accepting the published figures and descriptions of some European authors. The radulae of the large planorboids of both Europe and America are essentially alike as far as general characteristics are concerned.

The American species form a homogeneous group agreeing in essential details. The large planorboid snails of Europe and America fall into two distinct groups differing widely in the form of the genitalia. A third group, *Indoplanorbis*, occurs in Asia, and differs from both the European and the American species in the form of the genitalia. Whether the large planorboid snails of Africa and Madagascar are like *Planorbis corneus* in general anatomy or represent another group is not at present known. From the information at present available the large planorboid snails of Europe, Asia, and America may be included under three genera, the details of which are noted below.

Genus *PLANORBIS* O. F. Müller, 1774.

Planorbis O. F. Müller, 1774, Verm. Terr. Fluv. Hist. ii. p. 152. Genotype, *Helix cornea* Linn. as designated by Denys de Montfort, Conch. Syst. ii. p. 270 (1810).

The type of the genus *Planorbis* has been in some dispute. Dall (1905, p. 84) assigns the *Helix cornea* of Linnæus as type, citing Montfort, 1810, as the first author to designate a type for Müller's genus. Some English authors (Kennard & Woodward, 1924, p. 9), however, give the name to Geoffroy, a non-binomial author, with *Helix planorbis* Linn. as the type. It is also contended that the species *planorbis* is the type by tautonymy of *Planorbis* Müller, that species being listed by Müller among the names assigned to the genus. Many European students follow this interpretation. Recently (1927, p. 42) H. B. Baker has stated that the type of *Planorbis* Müller is *Planorbis carinatus* Müller. Pilsbry (1927, p. 115) accepts Dall's opinion that Montfort was the first to definitely select a type. On July 25, 1924, there was submitted to the International Commission on Zoological Nomenclature ('Science,' lx. no. 1543, p. 85) a list of names to be included among the official list of generic names, which included *Planorbis* Müller, 1774, with the type *Helix cornea* Linn. Several of the names listed were later included in the official list, but *Planorbis* was not among them. Amid the uncertainties and differences of opinion among systematists as to just what is the type of *Planorbis* and who first used the name the arbitrary selection of the type by the International Zoological Commission offers the best solution of the matter.

Coretus Gray (P. Z. S. 1847, p. 180), type *Helix cornea* Linn., is being used by many European students to include the large planorboid shells of Europe, notably Haas (1929, p. 378) and Wagner (1927, p. 303). Both of these authors consider the *Helix planorbis* Linn. the type of the genus *Planorbis* Müller, 1774. It appears obvious that as *Planorbis corneus* has been familiar to all students for a hundred years as the name for the large wheel-snails of Europe, and as there is such a wide difference of opinion in the interpretation of the type selection, such action by the International Commission as indicated above is the only solution, and should be accepted when made by all molluscan students. The *cornea* of Linnæus, as indicated by Dall, is retained as the type of the genus *Planorbis* in this paper.

Typical *Planorbis* is peculiar in the penial complex, the large preputial sac, the very small vergic sac and verge, the bilobed spermatophore gland, the elongated rounded sarcobelum appendage, with its sperm-duct in the form of an open channel on the appendage, the bulbous extremity of this appendage with its sensory mamma-like termination, and the peculiar method of discharging the spermatozoa from the verge into the open channel through an aperture in the spermatophore gland are features unknown in any other group of species of planorboid snails. The genus will include, besides the type *corneus*, such other species as agree with this type in the form of the genitalia. There are several species in Europe and in the British Isles which may be found to be recognizable after an examination of the radulæ as suggested under the description of *Planorbis corneus* in this paper. Species from Africa and western Asia referred to *Planorbis* cannot be definitely placed until the anatomy has been examined. *Biomphalia* Preston, 1910 (Ann. & Mag. Nat. Hist. (8) vi. p. 535), type *Biomphalia smithi* Preston, may be found to be different from typical *Planorbis* when the genitalia are examined. At present *Planorbis* typical is confined geographically to Europe.

Genus *HELISOMA* Swainson, 1840.

Helisoma Swainson, Malac. p. 337. Type, *Planorbis bicarinatus* Sowb.

As a subgeneric name *Helisoma* has been known in molluscan literature for many years. Binney (1865, p. 112), Tryon (1870, p. 188), and Dall (1905, p. 81) cite the name, using, however, only characteristics of the shell for its distinction. In 1928 Baker (I. p. 311) elevated the group to generic rank, basing the distinction on the peculiar genital complex of the male organ. *Planorbis trivolvis* was figured as typical of the general characteristics of the genitalia (fig. 140), and for the internal features the male organ of *antrosomum* was figured (fig. 143). The use of the name in a generic sense was first urged by the writer in 1926 (p. 201).

Authors generally have misquoted the type of this genus. The *Planorbis bicarinatus* of Sowerby, while a synonym of *Planorbis bicarinatus* Say, has nothing to do with Say's species, and Sowerby was probably not aware that there was another *bicarinatus*. It is a curious coincidence, however, that two authors should give the same name to the same species, the later author being unaware of the existence of the previous use of this name. Dall (1905, p. 84) cites the type as *Planorbis bicarinatus* (Say) Sowerby, which is incorrect, although the type is correctly cited on page 81. Another author (H. B. Baker, 1930, p. 43) cites *Planorbis bicarinatus* (Say) as the type, which is incorrect, Say's species dating from 1817, Sowerby's from 1824.

A careful study of Sowerby's description and his two figures on pl. clxxvii. (fig. 4) leaves no doubt of the unity of his species with that of Say. Binney (1865, p. 124) thought it might be *Planorbis campanulatus* Say, but both figure and description are undoubtedly *bicarinatus*. Binney based his opinion evidently on the lower figure 4 of the plate, which is not clear, and might be mistaken for *campanulatus*. There is no question about the upper figure being intended for *bicarinatus*. Unfortunately this appropriate name cannot be used, as it is preoccupied for a Paris Basin fossil (see Vanatta, 1911, p. 136). Conrad's *Planorbis antrosomum* replaces Say's *bicarinatus*, and thus is the type of *Helisoma*.

In typical *Helisoma* the penial complex (Pl. II.) is vase-like, characterized by a large preputial sac and a large vergic sac separated by only a slight constriction, the vergic sac very wide and somewhat bulbous. The duct of the spermatophore gland is very short, about the length of the preputial sac. The vas deferens enlarges as it enters the vergic sac to form an epiphallus. A single retractor muscle enters the columellar muscle, and a wide band or series of smaller retractor muscles enter the muscular integument of the fore part of the head. In some specimens the retractor muscle may be divided into two smaller muscles. The verge is large, cylindrical, capable of considerable extension through the vergic sac into the preputial sac and thence through the male opening. The spermatophore gland is elongated, conical, or somewhat pyriform, with a large cup-like opening divided into two compartments, one lined with large vertical folds which connect with the spermatophore duct, the other smooth or with very indistinct folds. The radula has bicuspid central teeth, tricuspid lateral teeth, and comb-like marginal teeth. The cusps of the lateral teeth are all sharply spear-shaped. The tooth formula is 27-1-27 or 30-1-30. The shell is typically bicarinate, both spire and base being depressed or funnel-shaped.

Typical *Helisoma* is widely distributed in North America from western Mexico, Texas, Louisiana, and Alabama northward to northern British America, at least as far north as Hudson Bay, and from Maine west to Oregon. This distribution includes the typical river form and the many varieties found in the

northern lake regions. The species and varieties known to belong to typical *Helisoma* are :—

- Helisoma antrosum* (Conrad) *.
- — *unicarinatum* (Hald.).
- — *portagense* (F. C. Baker).
- — *jordanense* (Winslow).
- — *minnesotense* F. C. Baker.
- — *aroostookense* (Pilsbry).
- — *royalense* (Walker).
- — *sayi* F. C. Baker.
- — *shellense* F. C. Baker.
- — *latchfordi* (Pilsbry).
- — *striatum* (F. C. Baker).
- — *cahni* F. C. Baker.

Another species and a variety are known which greatly resemble *antrosum* and may be found to be typical *Helisoma* when the animal is examined. These are :—

- Helisoma eucosmum* (Bartsch).
- — *vaughani* (Bartsch).

Paludina scalaris has been examined by Pilsbry and found to belong to *Helisoma*. No specimens have been available for examination by the writer, and the particular group of the genus to which this peculiar species may belong is not known.

Subgenus PLANORBELLA Haldeman, 1842.

Planorbella Haldeman, Mon. Lymn., Physidæ, p. 14 (1842). Type, *Planorbis campanulatus* Say.

In this group the vergic sac is long and pyriform and is greatly reduced in diameter where it is attached to the preputial sac. The preputial sac is large and pyriform, swelling to large dimensions just below the attachment of the vergic sac. This sac is placed at the summit of the preputial sac (Pl. IV. fig. 2). The spermatophore duct is more than twice the length of the vergic sac and preputial sac combined (Pl. IV. fig. 1). The verge is very long, elongate-pyriform, and rapidly diminishes in diameter toward the distal end. The spermatophore gland is about as wide as high or a little wider than high. The walls of the internal cup-like cavity are thicker on one side than on the other (Pl. IV. fig. 3). In this cavity the walls are all vertically folded (where the spermatophores are secreted), and in the bottom of the cavity (where the duct enters) there are many folds running crosswise but connecting with the folds of the walls. There may be a single posterior retractor muscle or this may be split into two branches. Anterior retractor muscles one or two in number. Radula as in typical *Helisoma*, but the mesocone of the lateral teeth wide and rounded, not pointed (Pl. VI. fig. 95). Typical *campanulatum* has the formula 23-1-23, and the central tooth of the radula measures as follows :—

Rows 1-94, 14 μ .

Rows 95-120, 12 μ .

This group differs notably from *Helisoma* typical in the widely different form of the preputial sac and the vergic sac, the great length of the spermatophore

* According to H. B. Baker (1930, p. 139) the genus *Helisoma* is a neuter and not a feminine noun, hence the endings of the specific names must be neuter adjectives, excepting in some arbitrary cases, as *trivolutis*, which must be considered an arbitrary combination of letters. The descriptions and figures of most of the varieties of *Helisoma* listed above will be found in volume I. of the 'Monograph of Wisconsin Fresh Water Mollusca' (Baker, 1928).

phore duct, and in the form of the cavity and folds of the spermatophore gland. The lateral teeth of the radula have the mesocone wider and bluntly rounded, not sharply pointed (Pl. VI. fig. 95, 1-13). The shells of this group also differ notably from those of typical *Helisoma*, *Planorbella* having the aperture peculiarly bell shaped in mature shells and the whorls of the spire are coiled in nearly
 The will clude the following species as

Helisoma

- (—)
- (—)
- (—)
- (—)
- (—) — *rudendrs* (Dall).
- (—) — *canadense* F. C. Baker.
- (—) *smithii* (—)

Planorbis multivolvis Case has been made the type of a subgenus *Adula* by H. Adams (P. Z. S. 1861, p. 145). Dall believes this separation to be unwarranted and that *multivolvis* should be included in *Planorbella*. *Adula* is preoccupied, however, and could not be used even if *multivolvis* should be found somewhat different in anatomical characteristics (*Adula* H. & A. Adams, 1857). The shell of *multivolvis* is so peculiar that one wonders just what the anatomy might be like. It should probably be included in *Planorbella* as suggested by Dall. The animal is unknown.

Subgenus *PIEROSOMA* Dall, 1905.

Pierosoma Dall, Alaska Moll. pp. 81, 85 (1905) Type, *Planorbis trivolvis* Say.

Pierosoma differs from *Planorbella* chiefly in the form of the shell, the aperture of which is not campanulate. The spermatophore duct varies in length in the different species from about one and a half to more than twice as long as the vergic and preputial sacs combined. The walls of the spermatophore gland are of the same thickness on all sides, the duct entering at about the centre of the base of the cavity (Pl. III. fig. 10; Pl. IV. fig. 6). The position of the vergic sac may be at the summit of the preputial sac (Pl. III. fig. 5) or it may be near the base of the preputial sac near the male external opening (Pl. III. fig. 7; Pl. IV. fig. 5). These different positions have been noted in specimens of the same species from one locality collected at the same time. This variation in position has been noted only in *Pierosoma*. The preputial sac appears to be more regularly pyriform in *Planorbella* than in *Pierosoma*. The lateral teeth of the radula in *Pierosoma* are somewhat wider and the mesocone of the teeth is wider and more rounded (Pl. VI.).

The great majority of the American species of large planorboid snails fall into this subgenus. The radula exhibits great variation among the different species in both formulae and size. The measurements of the central teeth of four characteristic species are given below as examples of this variation.

| <i>trivolvis</i> . | | <i>binneyi</i> . | | <i>magnificum</i> . | | <i>corpulentum</i> . | |
|--------------------|-----------------|------------------|-----------------|---------------------|-----------------|----------------------|-----------------|
| Row. | Size in μ . | Row. | Size in μ . | Row. | Size in μ . | Row. | Size in μ . |
| 1-20 | 18 | 1-104 | 18 | 1-9 | 17 | 1-21 | 18 |
| 21-73 | 20 | 105-150 | 17 | 10-65 | 20 | 22-95 | 20 |
| 74-93 | 21 | | | 66-90 | 17 | 96-123 | 18 |
| 94-153 | 20 | | | 91-128 | 15 | 136-150 | 17 |
| 159-183 | 17 | | | 124-180 | 14 | | |
| Formula. | | Formula. | | Formula. | | Formula. | |
| 31-1-31 | | 31-1-31 | | 43-1-43 | | 33-1-33 | |

Species thus far examined and known to belong to this group are :

- Helisoma* (*Pierosoma*) *trivolis* (Say).
- (—) — *pilsbryi* (F. C. Baker).
- (—) — *winslowi* (F. C. Baker).
- (—) — *plexatum* (Ingersoll).
- (—) — *binneyi* (Tryon).
- (—) — *chautauquense* F. C. Baker.
- (—) — *truncatum* (Miles).
- (—) — *magnificum* (Pilsbry).
- (—) — *corpulentum* (Say).
- (—) — *vermillionense* F. C. Baker.
- (—) — *pseudotrivolis* (F. C. Baker).
- (—) — *tenuis* (Phil.).
- (—) — *subcrenatum disjectum* (Cooper).
- (—) — *lentum* (Say).

Subgenus PLANORBINA Haldeman, 1842.

Planorbina Haldeman, Mon. Lymn., Physidæ, p. 14 (1842). No type cited.

Dall (1905, p. 84) designated *Planorbis olivaceus* Spix as the type, a species of the Province of Bahia, Brazil.

This group is practically unknown anatomically. The shells are vertically compressed, the whorls smaller and more numerous than in *Helisoma* or *Planorbis*, and the aperture is very oblique. Species assigned to this group have a wide distribution in tropical and subtropical America, extending as far north as Florida, Texas, and Louisiana. It is also found in the West Indies. The shape of the shell would indicate that the group should rank as a subgenus under *Helisoma*. No material has been available for anatomical study, and until such studies have been made the position of the group must be wholly tentative. The following species at least will be included in *Planorbina* :—

- Helisoma* (*Planorbina*) *olivaceum* (Spix).
- (—) — *guadelupense* (Spix & Wagner).
- (—) — *lugubre* (Spix & Wagner).
- (—) — *bahiense* (Dunker).
- (—) — *costaricense* (Preston).
- (—) — *glabratum* (Say).
- (—) — *druryi* (Wetherby).
- (—) — *intercalaris* (Pilsbry).

Genus INDOPLANORBIS Annandale & Prashad, 1920.

Indoplanorbis Annandale & Prashad, Journ. Ind. Medical Rec. viii. p. 112 (1920) ; Records Indian Museum, xxii. p. 578 (1921). Type, *Planorbis exustus* Desh.

This group differs from typical *Planorbis* in the structure of the branchial process and in the genitalia. Rao (1923, p. 215) figures the genitalia, showing the long and narrow vergic sac (penis) to be about as long as the preputial sac (penis-sheath), the latter wide and cylindrical, with thick walls. The vas deferens is figured as greatly enlarging as it approaches the vergic sac, this enlargement being as long as the vergic sac and about three times as wide. This is evidently to be regarded as an epiphallus. The verge is very long and narrow, the sperm-canal having its exit at the centre of the distal end. A single retractor muscle is attached to the vas deferens just before it reaches the vergic

sac. Rao does not mention the presence of a spermatophore gland or duct. The elongated muscular pads mentioned as being on each side of the preputial sac (penis-sheath) may represent this gland. *Indoplanorbis* is distinct from both *Planorbis* and *Helisoma*, and must be regarded as a genus. Its distribution is Indo-Chinese.

11. SUMMARY.

From the data presented in the previous pages it is evident that the large planorboid snails are divisible into three genera. Each has a form of genitalia peculiar to itself and different from any of the others. The radula does not afford characteristics of generic value, but may be used for subgeneric distinctions. The shells do not afford tangible generic characters, but may also be used for subgeneric distinction. The groups as now understood may be distinguished as follows :—

- | | |
|--|-----------------------|
| 1. Vergic sac appearing as an enlargement of the vas deferens, very small and narrow, about one-sixth as long as the preputial sac; verge very small, not evertible, but discharging the spermatozoa into a channel on an appendage connecting with the spermatophore gland, the appendage performing the function of a verge; no spermatophore duct; anterior and posterior retractor muscles attached to preputial sac | <i>Planorbis.</i> |
| 2. Vergic sac very large, wide, one-third of to as long as preputial sac; verge evertible, large, discharging spermatozoa directly into female opening; spermatophore gland forming a cup-shaped body with many folds in the cavity; a spermatophore duct of varying length connecting spermatophore gland with vergic sac, into which it opens just above a muscular diaphragm separating the two sacs; one retractor muscle, which may be split into two or more branches, attached to the preputial sac | <i>Helisoma.</i> |
| 3. Vergic sac very long and narrow, as long as the sac; verge long and slender, evertible; no spermatophore duct; spermatophore gland represented by heavy pads on the walls of the preputial sac | <i>Indoplanorbis.</i> |

The genus *Helisoma* is divisible into four subgenera, three of which may be diagnosed anatomically :—

- | | |
|--|---------------------|
| 1. Vergic sac nearly as wide as preputial sac, with but a slight constriction between the two sacs; duct very short, about as long as preputial sac; lateral teeth with mesocones sharply pointed | <i>Helisoma.</i> |
| 2. Vergic sac as long as preputial sac, pyriform, much narrowed at the constriction between the two sacs; duct very long, one and a half to more than twice as long as preputial sac; spermatophore gland with walls much thicker on one side; gland wider than high; mesocone of lateral teeth very wide and blunt; aperture of shell campanulate | <i>Planorbella.</i> |
| 3. Vergic sac as in 2; spermatophore gland with walls thickened on all sides; shell with aperture not campanulate | <i>Pierosoma.</i> |
| 4. Genitalia unknown; shell vertically compressed, whorls smaller and more numerous, aperture very oblique | <i>Planorbina.</i> |

A systematic arrangement of the genera and subgenera will appear as follows :—

Genus *Planorbis* Müller, 1774. Type, *Helix cornea* Linn.

Mainly European in distribution.

Genus *Helisoma* Swainson, 1840. Type, *Planorbis bicarinatus* Sowb.

North and South America and West Indies in distribution.

Subgenus *Helisoma* Swainson, typical. Type, *Planorbis bicarinatus* Sowb.

North America in distribution.

Subgenus *Planorbella* Hald., 1842. Type, *Planorbis campanulatus* Say.
United States and Canada in distribution.

Subgenus *Pierosoma* Dall, 1905. Type, *Planorbis trivolvis* Say.
North and Central America in distribution.

Subgenus *Planorbina* Hald., 1842. Type, *Planorbis olivaceus* Spix.
South America, Central America, Mexico, southern United States, and
West Indies in distribution.

Genus *Indoplanorbis* Annandale & Prashad, 1920. Type, *Planorbis exustus*
Desh.
Indo-China in distribution.

12. LITERATURE CITED.

- ANNANDALE, N., & PRASHAD, B. (1921.) The Aquatic and Amphibious Mollusca of Manipur. Records Indian Museum, xxii. 1-p. 529-633.
- BAKER, FRANK COLLINS. (1911.) The Lymnæida of North and Middle America, Recent and Fossil. Spec. Pub. Chi. Acad. Sci. 3, pp. i-xvi, 1-539.
- BAKER, FRANK COLLINS. (1926.) Nomenclatorial Notes on American Fresh Water Mollusca. Trans. Wis. Acad. Arts, Sci., Lett. xxii. pp. 194-205.
- BAKER, FRANK COLLINS. (1928.) The Fresh Water Mollusca of Wisconsin. Wis. Geol. Nat. Hist. Survey, Bull. 70. Vol. I. Gastropoda, pp. i-vii, 1-507; Vol. II. Pelecypoda, pp. i-vi, 1-495.
- BAKER, H. BURRINGTON. (1928.) Minute American Zonitidae. Proc. Acad. Nat. Sci. Phil. lxxx. pp. 1-44.
- BAKER, H. BURRINGTON. (1930 A.) The Mollusca collected by the University of Michigan-Williamson Expedition in Venezuela. Occ. Papers, Mus. Zool. Univ. Mich. 210, pp. 1-94.
- BAKER, H. BURRINGTON. (1930 B.) Gender in Generic Names. 'Nautilus,' xliii. pp. 319-140.
- BAUDELOT, M. (1863.) Recherches sur l'appareil générateur des Mollusques gastéropodes. Ann. des Sci. Nat. ser. 4, Zool. xix. pp. 135-222, 268-294.
- BINNEY, W. G. (1865.) Land and Freshwater Shells of North America.—Part II. Pulmonata, Limnophila, and Thallasophila. Smith. Miscel. Coll. no. 143, pp. 1-161.
- BUCHNER, O. (1891.) Beiträge zur Kenntnis des Baues der einheimischen Planorbiden. Jahreshefte des Vereins für Vaterländische Naturkunde Württemberg. xlvii. pp. 35-118.
- DALL, WILLIAM H. (1905.) Land and Freshwater Mollusks. Harriman Alaska Exped. xiii. pp. 1-171.
- HAAS, F. (1929.) Fauna Malacologica Terrestre Y de Agua Dulce de Cataluña. Trabajos del Museo de Ciencias Nat. de Barcelona, xiii. p. 491.
- HALDEMAN, S. S. (1840-44.) A Monograph of the Limniades and other Freshwater Univalve Shells of North America. Philadelphia.
- KENNAED, A. S., & WOODWARD, B. B. (1924.) Nomenclatorial Notes relating to British Non-marine Mollusca. II. Proc. Mal. Soc. London, xvi. pp. 7-14.
- KENNAED, A. S., & WOODWARD, B. B. (1926.) Synonymy of the British non-marine Mollusca (Recent and Tertiary). British Museum, London, pp. i-xxiv, 1-447.
- MOQUIN-TANDON, A. (1855.) Histoire Naturelle des Mollusques Terrestres et Fluviales de France. Paris. Two volumes.
- PILSBRY, HENRY A. (1894.) Guide to the Study of Helices. Man. Conch. ser. 2, ix. pp. i-xlvi, 1-366.
- PILSBRY, H. A., & BEQUAERT, J. (1927.) The Aquatic Mollusks of the Belgian Congo, with a Geographical and Ecological Account of Congo Malacology. Bull. Amer. Mus. Nat. Hist. liii. pp. 69-602.
- RAO, H. SRINIVASA. (1923.) On the Anatomy of *Indoplanorbis exustus* (Mollusca Pulmonata). Records Indian Museum, xxv. pp. 199-219.
- SIMMONS, H. (1912.) Mollusca. In Bronn and Keferstein, Klassen und Ordnungen der Weichthiere, iii.

- TAYLOR, JOHN W. (1894-1900.) Monograph of the Land and Freshwater Mollusca of the British Isles, pp. 1-454.
- TRYON, GEORGE W. (1870.) A Monograph of the Freshwater Univalve Mollusca of the United States. (In continuation of Prof. S. S. Haldeman's work published under the same title.) Philadelphia, pp. 1-238.
- WAGNER, ANTONI. (1927.) Studien zur Molluskenfauna der Balkenhalbinsel mit besonderer Berücksichtigung Bulgariens und Thraziens, nebst monographischer Bearbeitung einzelner Gruppen. Annales Zool. Musei Polonici Hist. Nat. vi. pp. 263-399.

13. ADDITIONAL NOTE.

Since the foregoing pages were completed nearly one hundred additional dissections of *Helisoma* have been made, the resulting information from which changes or modifies some of the views previously held. In specimens of *Helisoma lentum* (Say), from New Orleans, the type-locality, the spermatophore gland was observed protruding from the male opening near the left tentacle and lying on the neck, and the extreme end of the verge was also protruded and lying beside the gland. This was observed in a number of specimens. It is evident, therefore, that in *Helisoma* the transfer of spermatophores takes place outside the body of the animal, probably simultaneously with the ejection of the sperm. In these specimens with the exposed spermatophore gland it was observed that the muscles attached to the fore part of the neck and the anterior side of the preputial sac were functioning as retractors of the region of the gland, and are in no sense protractor muscles as at first considered. There are no protractors of the penial system, but a series of anterior and posterior retractor muscles, the former for the retraction of the spermatophore gland region and the latter for that portion of the preputial sac through which the verge protrudes. The extension of the verge and gland is apparently solely by blood pressure.

EXPLANATION OF THE PLATES.

All figures are from camera lucida drawings.

PLATE I.

Genitalia of *Planorbis cornuus* (Linn.).

Fig. 1. External form of penial complex.

2. Penial complex in vertical section, to show position of organs.

3. Spermatophore gland and appendage with sarcobelum from above.

4. The same organ from the side. A.P. Portion attached to walls of preputial sac. P.P. Free portion in cavity of preputial sac.

5. Spermatophore gland cut open to show sperm-canal extending through opening to vergio sac.

6. Distal end of verge, showing position of opening of sperm-canal and position of appendage.

7. Vergio sac cut open to show position of verge at upper end where vas deferens enters verge; viewed from above looking toward vas deferens.

8. Verge from side, showing position of appendage when organ is at rest.

9. Cross-section of spermatophore-gland appendage, showing position and character of sperm-groove or canal.

The organs are labelled as follows:—

A. Spermatophore gland appendage. E.V.D. External opening of vas deferens. G.L. Spermatophore gland. M. Sensory termination of sarcobelum. N. Bifurcating nerve to region of vergio sac. O.C. Opening of sperm-canal in spermatophore gland. P.A. Vergio appendage. P.M. Anterior retractor muscles of penial complex. P.R. Preputial sac. R.M. Posterior retractor muscles of penial complex. S. Sarcobelum. S.C. Sperm-canal. V. Verge. V.S. Vergio sac. V.D. Vas deferens.

Measurements are in lower left corner of plate and represent one millimetre; they may be interpreted as follows: upper line, figs. 1, 2; middle line, fig. 4; lower line, figs. 3, 5. Figures 6, 7, and 8 are greatly enlarged.

PLATE II.

Genitalia of *Helisoma antrosom* (Conrad).

- Fig. 1. Penial complex, external form, the spermatophore duct detached from preputial sac and spread out.
 2. Penial complex cut in vertical section, to show position of organs, the diaphragm almost closed and the verge retracted within the vergic sac. Exit and entrance of spermatophore gland-duct is indicated. Specimen of figs. 1, 2 from Unionville, Ct., in small stream.

Genitalia of *Helisoma antrosom percarinatum* (Walker).

3. Penial complex in vertical section, to show position of organs. The diaphragm is open and the verge is extended through it into the preputial cavity.
 4. Vertical section of proximal part of verge and vergic sac, to show position of epiphallus on vergic sac and its connection with the verge. Also space in verge.
 5. Transverse sections of verge. The letters *a*, *b*, *c*, *d*, *e* show positions of section as indicated on verge in fig. 3.
 6. Distal end of verge showing stylet-like termination and outlet of sperm-canal, from below.
 7. Same organ viewed from the side.
 8. Diaphragm of *Helisoma antrosom* in closed condition.
 9. Diaphragm of *Helisoma antrosom* in open condition.
 10. Diaphragm of variety *percarinatum* closed, but in dependent position.
 11. Epiphallus of variety *percarinatum*, showing position of vas deferens opening. Sections of organ in two places as indicated.
 12. Section of spermatophore gland of variety *percarinatum*, showing the two cup-like cavities at distal end of gland and position of duct as it leaves the preputial sac.

The organs are labelled as follows:—

B. Body-wall of gland. *D.* Diaphragm. *D.C.* Spermatophore gland-duct. *D.G.* Duct from preputial sac. *D.V.* Duct entering vergic sac. *EPI.* Epiphallus. *G.L.* Spermatophore gland. *G.W.* Wall of preputial sac. *I.C.* Cavity of gland connecting with gland-duct. *O.C.* Outer cup of gland. *P.M.* Retractor muscles. *PR.* Preputial sac. *R.* Muscular ring. *R.M.* Retractor muscle. *S.* Stylet-like appendage of verge. *S.C.* Sperm-canal. *V.* Verge. *V.C.* Vergic space. *V.D.* Vas deferens. *V.F.* Vergic folds. *V.S.* Vergic sac.

Measurements in lower right corner of plate represent one millimetre and may be applied as follows:—Reading from left to right: first line, figs. 3, 8, 9; second line, figs. 1, 2; third line, figs. 4, 5, 6, 7, 10; fourth line, fig. 12; fifth line, fig. 11. Specimens of variety *percarinatum* from Douglas Lake, Michigan.

PLATE III.

- Fig. 1. Spermatheca of *Helisoma antrosom* (Conrad) filled with spermatophores.

Genitalia of *Helisoma (Piersosoma) trivolvis* (Say).

2. Vertical section of vergic sac and verge, showing cavity in centre of verge.
 3. Diaphragm from below, closed.
 4. Section of vergic sac and preputial sac, showing diaphragm (closed) and position of verge and entrance of duct from spermatophore gland.
 5. Penial complex with duct of spermatophore gland separated from preputial sac and spread out to show length of duct.
 6. Vertical section of penial complex, showing position of verge and spermatophore gland, with wide diaphragm separating vergic sac from preputial sac. Vergic sac at summit of preputial sac.
 7. Penial complex in section, showing vergic sac near base of preputial sac.
 8. Penial complex, showing natural position of spermatophore gland-duct between vergic sac and preputial sac, the former bent downward.
 9. Spermatophore gland in normal position; a somewhat elongated specimen.
 10. Spermatophore gland in vertical section, showing relation of internal cavity or cup to duct.

The symbols on figures as in Plate II. excepting the following:—

F.O. Female opening. *G.F.* Folds in wall of gland-cavity. *I.C.* Folds in bottom of cavity. *O.C.* Large cavity in distal end of spermatophore gland. *SP.* Spermatheca. *SPM.* Spermatophores in spermatheca. *VA.* Vagina.

Measurements in lower right corner of plate represent one millimetre and may be applied as follows, reading from left to right: first line, figs. 5, 6, 7, 8; second line, fig. 1; third line, figs. 9, 10; fourth line, figs. 2, 3, 4.

PLATE IV.

Genitalia of *Helisoma (Planorbella) campanulatum* (Say).

- Fig. 1. Penial complex, external form, with duct of spermatophore gland separated from preputial sac and spread out to show length.
 2. Penial complex in vertical section, showing position of verge and spermatophore gland.
 3. Vertical section of spermatophore gland, showing form of cavity and position of duct.

Genitalia of *Helisoma (Pierosoma) truncatum* (Miles).

4. Duct of spermatophore gland, showing small muscles which attach the duct to the general covering of the preputial sac.

Genitalia of *Helisoma (Pierosoma) tenue* (Phil.).

5. Penial complex with vergic sac attached to preputial sac near base. Vertical section also shows position of verge and spermatophore gland and its duct.
 6. Vertical section of spermatophore gland, showing form of cavity.
 7. Portion of penial complex, showing position of opening of gland-duct into vergic sac just above the diaphragm.

Symbols as in Plate III.

Measurements at bottom of plate represent one millimetre and may be applied as follows : upper line, fig. 5 ; middle line, figs. 1, 2 ; lower line, figs. 3, 4, 6, 7.

PLATE V.

Radula of *Planorbis corneus* (Linn.).

Fig. 72. Central tooth of 72nd row ; 1-10, lateral teeth ; 11-45, marginal teeth, all of 72nd row : specimen from Germany. Fig. 75. Central tooth of 75th row ; 1-10, lateral teeth ; 12-14, transition teeth ; 15-25, marginal teeth ; 40, an outer marginal tooth : aquarium specimen, locality unknown. Line at bottom of plate represents 25 microns.

PLATE VI.

Radula of *Helisoma antrosom* (Conrad).

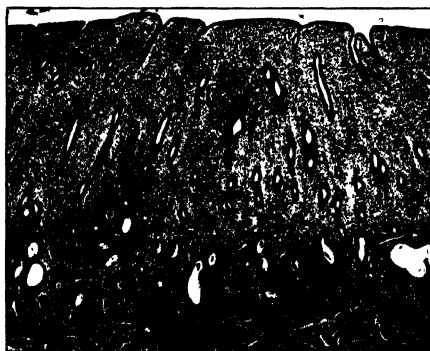
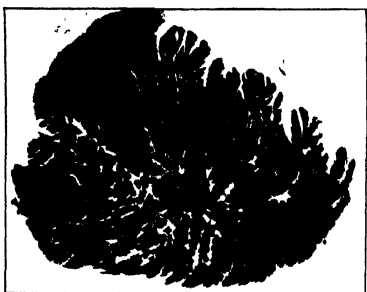
Fig. 15. Central tooth of 15th row. 1-5, lateral teeth ; 6, 7, intermediate teeth ; 8-14, marginal teeth, all of 15th row. Fig. 4. An abnormal lateral tooth, the ectocone split into four small cusps : specimen from Maple River, Michigan.

Radula of *Helisoma (Planorbella) campanulatum* (Say).

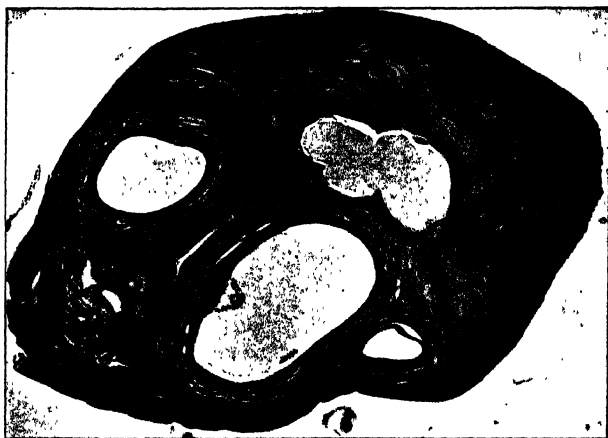
Fig. 95. Central tooth of 95th row. 1-7, lateral teeth ; 8, 9, transition teeth ; 10-13, marginal teeth, all of 95th row : specimen from Oneida Lake, New York.

Radula of *Helisoma (Pierosoma) trivolvis* (Say).

Fig. 53. Central tooth of 53rd row. 1-11, lateral teeth ; 12, transition tooth ; 13-18, marginal teeth ; 23, outer marginal tooth, all of 53rd row : specimen from Bayfield, Wisconsin. Line at bottom of plate represents 25 microns.



MENSTRUAL CYCLE OF THE PRIMATES.



7



8



9

MENSTRUAL CYCLE OF THE PRIMATES.

34. The Menstrual Cycle of the Primates.—Part IV. Observations on the Lactation Period. By S. ZUCKERMAN, M.A., M.R.C.S., L.R.C.P., Anatomist to the Society, and Demonstrator of Anatomy, University College, London.

[Received May 12, 1931; Read May 26, 1931.]

(Plates I. & II.)

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I. INTRODUCTION.

The question of lactation was briefly considered in Section VIII. of Part I. of this series of papers (Zuckerman, 1930, pp. 732–737). Observation of sexual-skin changes suggests (1) that a "lactation interval," during which ovarian and uterine cycles do not occur, follows parturition in sub-human primates; and (2) that if suckling is abruptly discontinued during a lactation interval (for instance when the baby dies), or if lactation is not established (*i. e.*, if the baby is still-born or dies soon after birth), only a short interval elapses before the onset of a menstrual cycle, which usually begins with swelling of the sexual-skin. It was noted, for instance, that the lactation interval in the chimpanzee lasts from 18 to 21 months, judging by the absence of menstruation; but if the animal does not nurse its young, a menstrual cycle begins about 2 weeks after parturition.

In normal circumstances nursing continues long after the lactation interval of ovarian and uterine inactivity has ended. A young ape, for instance, is breast-fed for much longer than the lactation interval, in one recorded case for at least 4 years*.

In a Pig-tailed Macaque (*M. nemestrina*) the lactation interval lasted 8 months. The baby continued to suck for nearly a year, although it had been eating solid food from the time it was 4 weeks old.

* This was a baby orang that died in the London Zoological Gardens. Its age was estimated from analogy with the times of tooth eruption in the chimpanzee, and given in Part I. p. 733 as 5 or 6 years. According to Brandes (1931), who provides data for the orang, its age could have been anything between 3½ and 7 years. Four is therefore given here as the more conservative estimate.

Some data regarding the lactation interval in baboons were also recorded, and a complete lactation interval that lasted 149 days was noted in Part III. (Zuckerman, 1931, p. 327). The length of time that a young baboon would continue to take the breast is unknown, but it is certainly longer than the lactation interval. Like other Old-World monkeys, young baboons begin to eat solid food when about 4 weeks old. If the mother stops nursing before the end of the lactation interval, 10 to 20 days elapse before her sexual-skin begins to swell.

New observations recorded in this paper provide some anatomical confirmation for the view that a period of ovarian and uterine inactivity follows parturition in sub-human primates.

II. MATERIAL AND OBSERVATIONS.

a. *MACACA NEMESTRINA*. Pig-tailed Macaque.

The same female mentioned above became pregnant on the 17th of December, 1929, and gave birth in the night between the 6th and 7th of June, 1930, after 171 days of gestation (calculated from the last subsidence of sexual-skin swelling). There was lochia for 5 days. The baby, a female, continues to suck (12/5/31), but it is not known whether or not milk is still being secreted. She is no longer dependent on her mother, but eats freely of the food put into the cage.

Some time in September the mother's sexual-skin gradually became deeply coloured. It is impossible to give an exact date for the onset of this change, as the coloration was not accompanied by swelling. She continued in that state until the 9th of January, when she began to menstruate, bleeding continuing for 6 days. There was no further change in the sexual-skin until the 27th of February, when it appeared to be somewhat swollen. Blood was found on the perches of the cage between the 2nd and 6th of March, but she was not actually seen to be menstruating. So far as could be seen, neither she nor her baby had any abrasions to account for the blood, and it is quite possible that she was menstruating on those days; (it was impossible to be sure of this point, as this exhibition animal is too fierce to be handled). The sexual-skin continued to swell for a few days, and then stopped, at a stage somewhat less than midway between the quiescent and fully swollen stages. About the 20th of March swelling recommenced, and in 10 days reached its maximum. On the 8th of April absorption suddenly began, and 4 days later the sexual-skin was at its resting level. Fifteen days from the beginning of absorption (23rd April) she began to menstruate, bleeding continuing for 4 days, when her sexual-skin again began to swell.

As indicated above, it is impossible to be certain of the date when this lactation interval ended. The first menstruation occurred 216 days after parturition, and presumably cyclical uterine activity began at least 30 days before that. Her previous lactation interval had ended with sexual-skin swelling about 8 months after parturition, the first menstruation occurring 71 days from the onset of swelling and 304 days after parturition. The fact that succeeding lactation intervals ended with different manifestations of the menstrual cycle, the one with menstruation, the other with sexual-skin swelling, is interesting, as this animal has in the past shown a cycle without any sexual-skin swelling, as well as a cycle in which the sexual-skin swelling did not subside (see Chart 3, p. 707, Part I.).

b. *MACACA IRUS*. Common Macaque. M. 61. 1038/30.

A nursing Common Macaque arrived in the London Zoological Gardens on the 2nd of September, 1930. Her baby's teeth were examined a fortnight later, and from Spiegel's data (1929) it was estimated to be 60 days old, although its weight (226 grm.) was less than half that of Spiegel's specimen at that age (507 grm.). The mother became so wasted and weak that she was killed on the 10th of November, approximately 114 days after parturition. She did not menstruate or show sexual-skin changes while in the Gardens.

In the following description her reproductive organs are compared with those of a "virgin" adult Common Macaque (M. 95, DB.151/31). This animal will be referred to as the control.

M. 95, DB.151/31 had been 5 years in the Gardens, and had never, so far as is known, borne young. She was killed because the intractable poor condition of her coat made her unfit for exhibition. Otherwise she was perfectly healthy; at post-mortem none of her internal organs showed any sign of disease. Her last observed menstruation occurred 85 days previous to her death. There was a prominent 2.7 mm. follicle in her right ovary (the diameter of the mature follicle in the allied species *mulatta* is 4 mm. (Corner, 1923)); and the remains of a corpus luteum were embedded deeply in the substance of the left ovary, lying closely against the theca externa of a large follicle (diameter 2.05 mm.). The endometrium, as would be expected from the state of the ovaries, was in the "interval" phase. The glands were not coiled.

Examination of the reproductive organs of the nursing monkey M. 61 showed them to be in an inactive state.

Mammary Glands.

At death milk could not be expressed from her mammary glands, though they still showed marked lactation hypertrophy (see Pl. I. figs. 1 & 2).

Ovaries.

Macroscopic.—The ovaries were small and contracted. Two minute translucent areas (small follicles) were visible on the surface of the left ovary.

Microscopic.—The ovaries were serially sectioned at 10 μ , the sections mounted one in five, and stained in Meyer's hæmalum and acid fuchsin.

Each ovary contains about six perfectly healthy resting follicles 1 mm. in diameter. Several smaller follicles are also present. Neither ovary shows any sign of a corpus luteum, and both are characterized by increased vascularity and a large number of atretic follicles. The arrangement of the latter suggests that the majority of developing follicles, as they grew into the interior of the ovary from the primary oocyte layer, became atretic. The effect was to make the ovary appear to be built of layers of different structures—a central core of large blood-vessels, enveloped by a thick zone of atretic and resting follicles, that in turn is invested by the layer of primary oocytes covered with a fibrous capsule. The stratum of atretic follicles is very distinct and sharply marked.

The atretic follicles are mostly fairly typical thick fibrous walled cysts, up to 400 μ diameter, generally empty, but some containing the remains of the degenerated ovum. There is no antrum to many of these atretic follicles, which differ from the type of atretic follicle seen in the control ovary chiefly in the thickness of their walls and the amount of hyaline change they show (see Pl. I. figs. 3 & 4).

Uterus.

Macroscopic.—The uterus was much smaller than that of the control.

Microscopic.—The endometrium is very low. No gland extends from the epithelial lining of the uterus for more than 1 mm. into the stroma (in the interval endometrium of the control they extend as much as 3 mm.). The line of demarcation between mucous membrane and muscle is much more irregular than in the control, muscle-fibres extending into the deep part of the stroma that is devoid of glands.

The nuclei of the stroma are very densely packed, much more so than in the control. The epithelium of the cavum uteri and glands, as in the control, is composed of irregular columnar cells with large vesicular nuclei, and most glands are empty.

There are a large number of changes to be seen in the lactation uterus none of which are to be found in the control, indicating that involution was still in progress at the time of death.

Scattered in the stroma and in the muscle layers are large phagocytic cells, some containing vacuoles similar to the vacuoles left by fat, and others carrying pigment granules, doubtless the remains of the hæmorrhage of parturition. In places there are large accumulations of these cells, some raising the lining epithelium of the cavum uteri. The pigment granules, which are numerous near vessels, are mostly intracellular, but there are a few that appear to be extracellular. Patches of hyaline degeneration are also to be found both in the stroma and in the muscle-layers. Usually they can be seen to be related to blood-vessels, but in places, especially in the stroma, it is impossible to tell whether or not they started as degenerative changes in the walls of blood-channels. The vessels of the myometrium show the typical involution changes that are found in the puerperal human uterus, appearing as thick-walled channels showing considerable hyaline degeneration. The cavum uteri contains débris, consisting mostly of necrotic cells, and a few nuclei in various stages of disintegration. The débris seems to consist of cast-off epithelial cells and phagocytic cells that have migrated through the epithelial lining, which in places is thin and appears to be syncytial in type. One breach in the continuity of the epithelial seems to be "natural" (see Pl. I. figs. 5 & 6).

Apart from their inactive appearance, the particular feature of the reproductive organs of this nursing monkey is the exaggerated degree of follicular atresia. It is possible that this was due—at any rate partly—to inanition. Though there was no obvious pathological change found in any of her organs at post-mortem, the animal was very wasted, the cause being a heavy helminthic infection of the alimentary canal. (The worms found were *Trichuris trichiura*, *Oesophagostomum apistomum*, and *Chlamydonema tumefaciens*.) Her weight, 1.165 kg., compares unfavourably with that of the control (M.95), 3.277 kg. There can be little doubt that inanition was responsible for the cessation of lactation, for, according to Spiegel (1929), the Common Macaque should continue to secrete milk for at least 1½ years after parturition. It is therefore possible that the exaggerated degree of atresia in the ovaries was also partly due to the effects of general inanition. It must be remembered, however, that the number of follicles that become atretic is increased during gestation and doubtlessly also during a lactation interval, as for instance, during the lactation interval of the Baboon (described below). It is therefore improbable that inanition alone was responsible for the large number of atretic follicles found. It is, moreover, significant that the extent of follicular atresia seen in the ovaries

of this lactating Common Macaque, though greater than usually found in the ovaries of monkeys, would be considered normal in any phase of the adult human ovary.

c. *PITHECUS CRISTATA* (= *Pygathrix cristata*). Bornean Langur. M.46.

A nursing female of this species, 5.67 kg. in weight, was shot in Borneo on the 17th June, 1930, by Mr. E. Banks, Curator of the Sarawak Museum. The reproductive organs of both the mother and her 0.9 kg. female baby were fixed soon after death, and the material sent to England. It is possible to make only a very rough estimate of the length of time this female had been nursing, and that by comparative data.

Adult female hamadryas baboons (*Papio hamadryas*) vary round 9 kg. in weight. The young of the species weigh at term slightly less than 1 kg. (e. g., M. 38 b, -949 gm., somewhat less than 1/11th of its mother's weight). When 5 months old they may weigh no more than 1/7th of the adult weight (Wa, b, 1.344 gm.). Adult female chacma baboons (*Papio porcarius*) vary in weight round 18 kg. The young of the species weigh at term slightly more than 1 kg. (e. g., M. 29 b, -1.134 kg., which was a little more than 1/14th of its mother's weight). When two months old they may weigh no more than 1/13th (b, 1.347 kg.), and when 9 months a little more than 1/5th (c, 3.75 kg.) of the adult weight. At birth the Common Macaque (*Macaca irus*) weighs a little more than 1/10th of the weight of the mother, and when two months old about 1/6th (Spiegel, 1929, pp. 56-57). The Rhesus Macaque (*Macaca mulatta*) at birth weighs a little less than 1/13th of the mother's weight, and at two months a little more than 1/7th (Hartman, 1928).

So far as these data allow of any generalization, they indicate that, as a rule, a monkey at birth weighs less than 1/10th of the mother's weight, and that it does not reach 1/6th of her weight for at least two months.

The baby of the Langur shot by Mr. Banks weighed a little less than 1/6th of the weight of its mother. One can therefore make the cautious estimate that the Langur had been lactating for at least two months before she was shot.

Examination of her reproductive organs revealed no sign of recent cyclical activity.

Ovaries.

Macroscopic.—The ovaries were small and contracted.

Microscopic.—Sections prepared as in the preceding case.

Neither ovary contains any sign of a corpus luteum. Each ovary contains about six medium-sized follicles, the biggest having an average diameter of 2.2 mm. Both also contain several typical atretic follicles showing hyaline change, and each shows a large hyaline patch similar in nature to a corpus candidans (Shaw, 1926). The right ovary also shows pigment granules in its hilum, probably the remains of a small hæmorrhage (see Plate II. fig. 7).

Uterus.

Macroscopic.—The uterus appeared to be small and inactive.

Microscopic.—The endometrium is very low. The glands, which are straight and wide, do not extend more deeply than 0.5 mm. The line of junction of muscle and stromal cells is irregular. The stromal nuclei are somewhat densely packed. The surface and glandular epithelium is composed of irregular columnar cells with oval vesicular nuclei.

As in the case of the Common Macaque, there are many signs that indicate

that the process of involution was still active at the time of death. There are, however, fewer phagocytic cells, and the amount of pigment granules to be seen is less than in the Macaque. Several patches of hyaline degeneration are to be seen in the endometrium. In the cavum uteri, and in some of the glands, is debris made up of necrotic material, polymorphs, large phagocytic cells, and epithelial cells. There is no definitely natural breach in the glandular or surface epithelium (see Pl. II. fig. 8).

The presence of follicles of over 2 mm. in diameter in the ovaries of this monkey suggests that she was shot towards the end of her lactation interval.

d. *PAPIO PORCARIUS*. Chacma Baboon.

In Part III. of this series (Zuckerman, 1931, p. 331) reference was made to four lactating females of the species *P. porcarius* that were shot in South Africa (M. 20, 21, 28, 37). The stage of lactation was fairly accurately estimated in three (20, 21, 28) by examination of the teeth of their young. Two had been shot about two months, and the third about four months, after parturition. It was, however, impossible to tell which of the three females had the older baby, as the young ones had become separated from their mothers during the hunt. The baby of the fourth (37) was not obtained. The collector attached to the note accompanying the uterine specimen the remark that the baby was two months old; he did not, however, disclose his method of arriving at such an estimate.

None of these four lactating females showed any sexual-skin swelling.

Macroscopically and microscopically their uteri and ovaries were all practically alike. None showed any sign of recent cyclical activity. In the short description given below comparison is implied with the ovarian and uterine phases of the normal cycle, of which a full description will be given in Part V. of this series of papers.

Ovaries.

Macroscopically they appear small and shrunken. Only resting follicles are present (0.8–1.0 mm.). There is no sign of a corpus luteum, and the picture presented is one of complete rest. There are more atretic follicles than are found during the menstrual cycle. Their walls are not so fibroid, nor do they show as much hyaline change as those of the Common Macaque (M. 61) previously described.

Uterus.

The uteri taken from the four nursing females were shrunken in size, and, except in the transverse fundal diameter, were markedly smaller than uteri removed from females killed in different phases of the menstrual cycle. The cavum uteri was widely open in all, and filled with a coagulum.

The endometrium is low, and the glands, many of which are widely open and branched—though not coiled,—do not extend deeper than 1.3 mm. (During the "interval" phase they extend 3.5 mm., and during the luteal phase even deeper.) The line of junction of mucous membrane and muscle is, as at other times, fairly regular. The stromal nuclei are more tightly packed than they are during the interval phase, especially towards the base of the endometrium. The surface and glandular epithelium is composed of columnar cells of varying sizes, with large vesicular nuclei. Some cells can be seen falling off into the glands and the cavum uteri.

All four uteri, as in the Common Macaque M. 61, and the Langur M. 46,

show signs indicating that involution was still proceeding when the animals were shot. These degenerative signs cannot be seen in the interval and luteal phases of the normal cycle. The changes are not identical in all four specimens, but together they reproduce the same picture as that seen in the Common Macaque and Langur.

There are small patches of hyaline degeneration in the muscle and stroma; most vessels show marked hyaline changes in their walls. Hemosiderin granules are scattered in the stroma and muscular layers; a few seem to be extracellular, while most are included in swollen phagocytic cells. The cavum uteri and many of the glands are packed with necrotic debris consisting of amorphous material, phagocytic cells, polymorphs, and epithelial cells. There is no definitely natural breach in the uterine epithelium (see Pl. II. fig. 9).

III. DISCUSSION.

These new data provide anatomical support for the conclusion, drawn in Part I. from sexual-skin observations, that sub-human primates experience a period of uterine and ovarian inactivity after parturition. They also indicate that several months pass before all the debris of parturition is removed from the uterus.

Many mammals, besides monkeys and apes, neither ovulate nor show signs of uterine activity during lactation. The nature of the mechanism underlying this lactation interval is, in the case of the mouse, fairly well understood. It appears that the stimulus of sucking affects the anterior lobe of the pituitary, to whose activity can be ascribed the development and persistence of corpora lutea after the post-partum ovulation. It is doubtful, however, whether or not these corpora lutea are functional throughout the lactation interval of three weeks. When that period has passed sucking no longer suppresses the oestrous cycle, for it seems that foster-mothering, though it may prolong lactation considerably, does not extend the quiescent interval. That sucking is the primary cause of the lactation interval is proved by the fact that oestrus follows within two to four days after the removal of the litter of young at any time during the three weeks' lactation interval (Parkes, 1926, 1929; Crew and Mirskaia, 1930; Deansley, 1930).

In mammals, like the ferret, that have no post-partum ovulation, the mechanism of "oestrus suppression" is presumably different. The ovaries of such mammals do not contain corpora lutea during the lactation interval, and consequently the inhibition of oestrus and ovulation cannot be in any way ascribed to the activity of luteal secretion. To this group belong the Baboon and probably other Old-World Primates (e. g., *M. nemestrina*, *M. irus*, *P. cristata*).

In the light of present-day knowledge of anterior pituitary and ovarian relationship*, the data suggest, as far as Primates are concerned, that the stimulus of sucking in some way affects the anterior lobe of the pituitary in the first six months of lactation, so that the ovarian cycle is suppressed, and that it is ineffective as a stimulus after that time. That the act of sucking is the primary stimulus in this chain of events, as it is in the case of the mouse, is proved by the resumption of menstrual cycles if sucking is discontinued before the lactation interval has ended. It must not be assumed, however, that the stimulus of sucking is necessarily transferred to the pituitary by any

* Nelson and Piffner (1930) have recently shown experimentally that the breakdown of the luteal growth of the guinea-pig mammary gland, resulting in the secretion of milk, is also due to the action of anterior pituitary substance.

nervous mechanism. The metabolic condition of the lactating mother may of itself inhibit pituitary activity. It is probable that the act of sucking is the primary stimulus, because it maintains the flow of milk, and that the cessation of milk-secretion when sucking is discontinued is due to the pressure exerted on the secretory cells by the milk that accumulates in the alveoli. It is also probable that the lactation interval comes to an end when the young animal ceases to be a drain on its mother—that is, when it is taking enough solid food to be potentially independent of her, even though the evidence is against such a view in the case of the mouse. This possibility could be explored experimentally by withholding solid food from young monkeys, in that way forcing them to be entirely dependent on the mother for a period longer than the usual lactation dioestrous interval, and controlling the experiment by varying the quantity of food taken by the mother; or, alternatively, by substituting a breast-pump in place of the baby of a nursing female during the lactation interval.

The fact that monkeys have a lactation dioestrous interval lasting about six months has important bearing on certain statements that appear in the literature.

For instance, it is quite probable that the nursing Common Macaque described by Heape (1897) as menstruating, had already been nursing for more than six months. Heape clearly states that the mother did not supply all the young one's nourishment, giving, however, as his opinion that she nevertheless supplied most of it. It is not clear on what he based this opinion.

It is because of Heape's statement that "menstruation undoubtedly occurs while the mother is nursing her young"—based on the foregoing case—that Van Herwerden (1905) rejected the conflicting opinion given her by Dr. Kerbert, of the *Natura Artis Magistra*, Amsterdam, and accordingly disregarded lactation as a possible cause for the smallness of some of the Common Macaque uteri in the Utrecht collection (see Part III. p. 340, Zuckerman, 1931). Although she suggested that possibly menstrual cycles may continue with diminished signs of activity during the period of lactation, she nevertheless decided that the small uteri in the Utrecht collection had been taken from females killed in a non-breeding season.

Her conclusion that the small uteri had been collected during a non-breeding season was criticised and rejected in Part III. as speculative. It lacked even the parallel support of evidence that proved the occurrence of a yearly season of lowered fertility*. In view of the facts recorded in this paper, it seems far more likely that the small uteri with low endometria, associated as they were with inactive ovaries, had been taken, partly at any rate, from lactating animals.

IV. SUMMARY.

1. A Pig-tailed Macaque (*Macaca nemestrina*) gave birth to a female baby after 171 days' gestation. The first menstruation occurred 216 days after parturition. There had been no sexual-skin swelling in the interval.

2. A nursing Common Macaque (*Macaca irus*, M. 61) was killed approximately 114 days after parturition. She was wasted, and post-mortem examination

* Dr. Van Herwerden very kindly placed at my disposal the data from which she constructed a curve that she interpreted as showing that *Tarsius spectrum* has an "inclination to a higher productivity in special oestrous cycles." This curve, seeing that it was constructed from absolute numbers, was criticised in Part III. (p. 341) as being inadequate for such a conclusion. When the figures are arranged on a percentage basis, as Dr. de Lange has done in a recently issued table, no significant seasonal variation in the birth-rate of this species is seen.

revealed worm-infestation of the intestines. Her mammary glands, though they still showed marked lactation hypertrophy, were not secreting milk at the time of death. Her ovaries were inactive, and showed a large number of atretic follicles. Her uterine mucous membrane was low, with short and straight glands, and showed signs indicating that involution was still proceeding at the time of her death.

3. A nursing Langur (*Pithecus cristata*, M. 46) was shot in Borneo at a time that is estimated to have been at least two months after parturition. The ovaries, though small and contracted, contained medium-sized follicles, the largest having an average diameter of 2.2 mm. There was no sign of a corpus luteum. Each ovary contained a large corpus candicans. The condition of her uterus was much the same as that of the nursing Common Macaque.

4. Four nursing Chacma Baboons (*Papio porcarius*, M. 20, 21, 28, 37) were shot in South Africa, two at a time estimated to have been two months, a third four months, and the fourth at an unknown time, after parturition. The reproductive organs of all four were in practically the same condition, and showed no signs of recent cyclical activity. The ovaries were small, containing no signs of corpora lutea, but only resting follicles. The uteri were small and inactive, with low endometria, and showed signs indicating that involution was still proceeding at the time of death.

5. These data, as well as sexual-skin observations recorded in Part I. of this series of papers, indicate that sub-human primates experience a period of uterine and ovarian inactivity after parturition. This fact is of importance in discussions relating to periods of reproductive inactivity in monkeys, *e. g.*, alleged breeding- and non-breeding seasons.

My thanks are due to Mr. E. Banks, of the Sarawak Museum, for his kindness in sending me the Langur material; and to Dr. Wilfred Shaw, of St. Bartholomew's Hospital, and Dr. W. G. Barnard, of University College Hospital, for their opinions on the histological material described in this paper. The Baboon material was obtained on an expedition that was financed partly by the Royal Society and partly by the Zoological Society of London.

V. BIBLIOGRAPHY.

- BRANDES, G. 1931. Wie alt wird der Orang-Utan? Zool. Garten, Leipzig, vol. iv. pp. 1-9.
- CORNER, G. W. 1923. Ovulation and Menstruation in *Macacus rhesus*. Contrib. to Embryol. No. 15. Carnegie Inst. of Washington, pp. 73-101.
- CREW, F. A. E., & MIRSKAIA, L. 1930. The Lactation Interval in the Mouse. Quart. Journ. Exper. Physiol. London, vol. xx. pp. 105-110.
- DEANESLY, R. 1930. The Corpora Lutea of the Mouse, with Special Reference to Fat Accumulation during the Estrous Cycle. Proc. Roy. Soc. London, B, vol. cvi. pp. 578-595.
- HARTMAN, C. 1928. The Period of Gestation in the Monkey (*Macacus rhesus*): First Description of Parturition in Monkeys, Size and Behavior of the Young. Journ. Mamm. Baltimore, vol. ix. pp. 181-194.
- HEAPE, W. 1897. The Menstruation and Ovulation of *Macacus rhesus*, with Observations on the Changes undergone by the Discharged Follicle.—Part. II. Phil. Trans. Roy. Soc. London, B, vol. clxxxviii. pp. 135-166.
- NELSON, W. O., & PRIFFNER, J. J. 1930. An Experimental Study of the Factors concerned in Mammary Growth and in Milk Secretion. Proc. Soc. Exper. Biol. & Med., New York, vol. xxviii. pp. 1-2.
- PARKES, A. S. 1926. Observations on the Estrous Cycle of the Albino Mouse. Proc. Roy. Soc. London, B, vol. c. pp. 151-170.
- PARKES, A. S. 1929. The Internal Secretions of the Ovary. Longmans, Green & Co., London.
- PARKES, A. S., & ZUCKERMAN, S. 1931. The Menstrual Cycle of the Primates.—Part II. Some Effects of Estrin on Baboons and Macaques. Journ. Anat. Cambridge, vol. lxx. pp. 272-278.

- SHAW, W. 1926. Fate of the Graafian Follicle in the Human Ovary. Journ. Obst. & Gyn. Manchester, vol. xxxii. pp. 1-11.
- SPIEGEL, A. 1929. Biologische Beobachtungen an Javamakaken, *Macacus irus* F. Cuv. (*cynomolgus* L.). Zool. Anz. Leipzig, vol. lxxxi. pp. 45-65.
- VAN HERWERDEN, M. 1905. Bijdrage tot de Kennis van Menstrueelen Cyclus en Puerperium. Brill, Leiden.
- ZUCKERMAN, S. 1930. The Menstrual Cycle of the Primates.—Part I. General Nature and Homology. Proc. Zool. Soc. London, pp. 691-754.
- ZUCKERMAN, S. 1931. The Menstrual Cycle of the Primates.—Part III. The Altered Breeding-season of Primates, with Special Reference to the Chacma Baboon (*Papio porcarius*). Proc. Zool. Soc. London, pp. 325-343.

VI. EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. A photograph of a carmine-stained stretched mammary gland preparation of a nursing Common Macaque (*Macaca irus*, M. 61, 1038 30). $\times \frac{1}{2}$.
2. A photograph of a carmine-stained stretched mammary gland preparation of a "virgin" Common Macaque (*Macaca irus*, M. 95, 151/31). $\times \frac{1}{2}$.
3. A section through the median plane of the left ovary of the nursing Common Macaque (M. 61), showing the layer of primordial follicles, beneath which is the zone of atretic and resting follicles and the central core of blood-vessels. $\times 9$.
4. A section through the left ovary of the "virgin" Common Macaque (M. 95), showing an old corpus luteum lying against the theca externa of a 2.05 mm. follicle. $\times 11$.
5. A transverse section of the uterus of the nursing Common Macaque (M. 61), showing the low endometrium, the short straight glands, the densely packed stromal tissue, the irregular line of junction of muscle and mucous membrane, patches of hyaline degeneration, and accumulations of phagocytic cells. $\times 30$.
6. A transverse section of the "interval" uterus of the "virgin" Common Macaque (M. 95), showing the deeper endometrium, the long straight glands, the lightly packed stromal nuclei, and the regular line of junction of muscle and mucous membrane. $\times 15$.

PLATE II.

- Fig. 7. A section through the median plane of an ovary of a nursing Langur, *Pithecus cristata*. (= *Pygathris cristata*) (M. 46), showing a corpus candidans lying close to a large follicle. $\times 13$.
8. A transverse section of the uterus of the nursing Langur (M. 46), showing the low endometrium with short wide glands, and patches of hyaline degeneration. $\times 18$.
9. A transverse section of the uterus of a lactating Chacma Baboon (*Papio porcarius*, M. 28), showing the low endometrium, with short glands, the tightly packed stromal nuclei, and small patches of hyaline degeneration. $\times 36$.

Photographs and photomicrographs by Mr. F. J. Pittock.

EXHIBITIONS AND NOTICES.

March 17th, 1931

Sir ARTHUR SMITH WOODWARD, LL.D., F.R.S., Vice-President,
in the Chair.

The SECRETARY read the following Report on the Additions to the Society's Menagerie during the month of February 1931 :—

The registered additions to the Society's Menagerie during the month of February were 180 in number. Of these 15 were acquired by presentation, 63 were purchased, 99 were deposited, 1 was received in exchange, and 2 were born in the Menagerie.

The following may be specially mentioned :—

2 American Mink (*Mustela vison*), deposited on February 13th.

1 Mariqua Sunbird (*Cinnyris bifasciatus mariquensis*), 1 Scarlet-breasted Sunbird (*Chalcomitra gutturalis*), from South Africa, and 1 Royal Starling (*Cosmopsarus regius*), from East Africa, presented by the Hon. Anthony Chaplin, F.Z.S., on February 2nd.

1 Manchurian Crane (*Megalornis japonensis*), deposited on February 25th.

2 Australian Thickknees (*Burhinus magnirostris*), purchased on February 28th.

Dr. V. E. NEGUS, F.Z.S., exhibited, and made remarks upon, specimens and reconstruction models of the Larynx of Dipnoi.

Miss E. M. BROWN, B.Sc., exhibited, and made remarks upon, a new Dinoflagellate.

April 14th, 1931.

Prof. E. W. MACBRIDE, M.A., F.R.S., Vice-President, in the Chair.

The SECRETARY exhibited a photograph of a bronze medallion of the Danish Zoologist, Peter Wilhelm Lund, born in Copenhagen in 1801, who died in 1880 in Brazil, where he had spent the greater part of his life. The Brazilian Government had recently placed a memorial bust of him on his grave at Lagoa Santa, and Danish friends had presented the medallion to the National Museum at Rio de Janeiro. In the Royal Society Catalogue of

Scientific Papers there was a long list of the titles of Lund's contributions to science. Lund was a naturalist who covered a wide field ranging from observations on Crustacea and Insects to Birds and fossil Mammals.

The SECRETARY exhibited a series of photographs of the "Monkey Hill" in the Lisbon Zoological Gardens.

April 26th, 1931.

SIR ARTHUR SMITH WOODWARD, LL.D., F.R.S., Vice-President,
in the Chair.

The SECRETARY read the following Report on the Additions to the Society's Menagerie during the month of March 1931 :—

The registered additions to the Society's Menagerie during the month of March were 130 in number. Of these 37 were acquired by presentation, 68 were purchased, 10 were deposited, 8 were received in exchange, and 7 were born in the Menagerie.

The following may be specially mentioned :—

A Snow-Leopard (*Felis uncia*), from the Highlands of Central Asia, purchased on March 12th.

3 Pandas (*Ailurus fulgens*), from the Eastern Himalayas, purchased on March 27th.

2 Semipalmated Geese (*Anseranas semipalmata*), from N.W. Australia, purchased on March 9th.

A collection of birds from the Gold Coast, including 1 Blue-beaked Weaver-Bird (*Spermospiza haematina*); 4 Tambourine Doves (*Tympanistria tympanistria*), and 1 Senegal Touraco (*Turacus persa buffoni*), presented by G. C. Upstone, Esq., C.M.Z.S., on March 19th.

Prof. E. HINDLE, F.Z.S., exhibited a pair of living Hamsters (*Oricetus auratus*) from Syria.

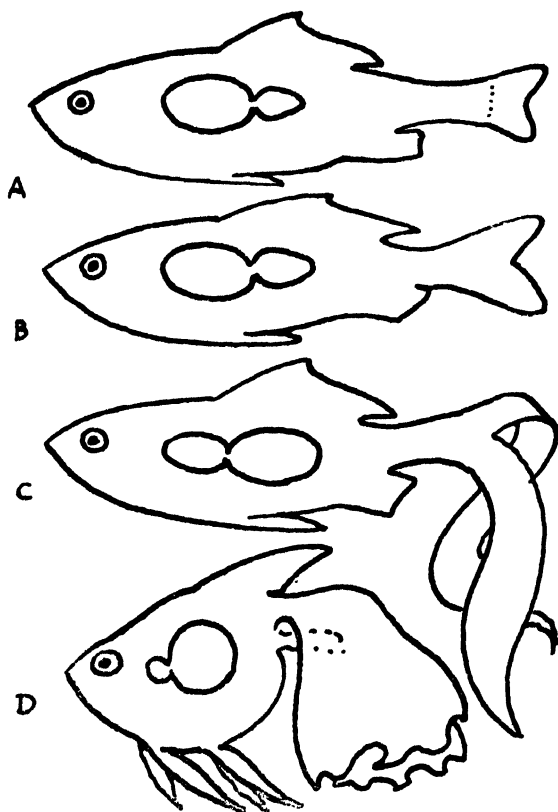
Mr. A. FRASER-BRUNNER, F.Z.S., exhibited a series of specimens demonstrating a correlation between the air-bladder and the caudal fin in the Common Goldfish (*Carassius auratus* Linn.), and made the following remarks :—

Examination of several thousands of Goldfish (*Carassius auratus*), of all varieties, shows that the proportion of the posterior lobe of the air-bladder to the anterior bears a direct relation with the proportion of the area of the caudal fin to the length of the body. Thus, a fish with normal body and unusually small caudal fin has the posterior lobe of the bladder smaller than in the normal (wild) variety, whereas a "fancy" fish, with short body and greatly enlarged caudal fin possesses a reduced anterior lobe and a much enlarged posterior lobe.

The adjustment of the gaseous contents of the air-bladder by the individual has been taken into consideration and allowed for.

The following examples and the text-figure will serve to illustrate the correlation. The proportions of the wild variety may be taken, for convenience, as :—Body-length, 6 ; tail area, 5 ; ant. lobe, 6 ; post. lobe, 5, pear-shaped.

Text-figure 1.



Relative sizes of the lobes of the Air-bladder in (A) Goldfish with small caudal fin ;
(B) common variety ; (C) Comet variety ; (D) Veiltail variety.

Comet variety :—Body-length, 6 ; tail area, 10 ; ant. lobe, 6 ; post. lobe, 10, oval.

Fantail variety :—Body-length, 3 ; tail area, 15 ; ant. lobe, 3 ; post. lobe, 15, spherical.

No doubt the phenomenon is due merely to the adjustment of the hydrostat to the altered centre of gravity.

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No. 330.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

February 3rd, 1931.

Prof. E. W. MACBRIDE, M.A., F.R.S., Vice-President,
in the Chair.

Dr. G. M. VEVERS read a Report on the Additions to the Society's Menagerie during the months of November and December, 1930.

Mr. G. C. ROBSON, M.A., F.Z.S., exhibited, and made remarks upon, the remarkable Cephalopod, *Cirrothauma murrayi*.

Mr. J. R. NORMAN, F.Z.S., exhibited, and made remarks upon, a Photograph of an abnormal Eel (*Anguilla anguilla* Linn.).

Mr. E. G. BOULENGER, F.Z.S., exhibited, and made remarks upon, an abnormal specimen of a Turbot (*Rhombus maximus*).

Mr. D. SETH-SMITH, F.Z.S., communicated some notes from a Diary on Wild Life observed at Whipsnade.

* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W. 8, on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

Dr. S. ZUCKERMAN, M.A., M.R.C.S., L.R.C.P., exhibited, and made remarks upon, a series of preparations of Primate Mammary Glands.

Mr. G. C. ROBSON, M.A., F.Z.S., gave a brief account of Mr. Frank Collins Baker's paper on "The Classification of the large Planorboid Snails of Europe and America."

Dr. N. B. EALES, C.M.Z.S., communicated her paper on "The Development of the Mandible in the Elephant."

Mr. A. D. MIDDLETON, communicated his paper "A Contribution to the Biology of the Common Shrew (*Sorex araneus* Linn.)."

In the absence of the Authors, the following Papers were taken as read :—S. MAULIK, M.A., F.R.M.S., F.E.S., F.Z.S., "On the Larva of the Poisonous Chrysomelid Beetle of N'gamiland, Africa"; CYRIL CROSSLAND, M.A., D.Sc., F.Z.S., "The reduced Building Power and the Variations in the Astrean Corals of Tahiti; with a Note on *Herpetolitha limax* and *Fungia* sp."; MARIE V. LEBOUR, D.Sc., F.Z.S., "(1) Further Notes on Larval Brachyura." (2) The Larvæ of the Plymouth Caridea.—I. The Larvæ of the Crangonidæ. II. The Larvæ of the Hippolytidæ.

The next Meeting of the Society for Scientific Business will be held on Tuesday, February 17th, 1931, at 5.30 P.M., when the following Communications will be made :—

H. C. WILKIE, F.R.C.V.S., F.R.M.S., F.Z.S.

The Middle Ear of the Horse (*Equus caballus*).

M. K. SEREBRENNIKOV.

On the Polychromatism and Albinism of the Siberian Squirrels,

W. S. BRISTOWE, B.A., F.Z.S.

- (1) A Contribution to the Knowledge of the Spider Fauna of South-West Ireland, and in particular the Islands off the Coast.
- (2) The Spiders of the Island of Grassholm, and some Additions to the Skomer Island List.

A. B. MISRA, D.Sc., F.Z.S.

On the Internal Anatomy of the Female Lac Insect, *Laccifer lacca* Kerr (Homoptera : Coccidæ).

The following Papers have been received :—

Major STANLEY S. FLOWER, O.B.E., F.L.S., F.Z.S.

Contributions to our Knowledge of the Duration of Life in Vertebrate Animals.—V. Mammals.

ELLIS LE G. TROUGHTON.

The Occurrence of a Male and Female *Grampus griseus* (Delphinidæ) at Sydney, New South Wales.

Dr. ERNST SCHWARZ.

A Revision of the Genera and Species of Madagascar Lemuridæ.

WILLIAM J. DAKIN, D.Sc., F.Z.S.

The Osmotic Concentration of the Blood of *Callorhynchus millis* and *Epiceratodus forsteri* and the Significance of the Physico-chemical Condition of the Blood in regard to the Systematic Position of the Holocephali and the Dipnoi.

The Rev. E. J. PEARCE, M.A., F.E.S.

Report on the Halipidæ (Coleoptera) : Mr. Omer Cooper's Investigation of the Abyssinian Freshwaters (Hugh Scott Expedition).

J. ST. LEGER.

A Key to the Families and Genera of African Rodentia.

I. FILIPJEV.

Report on Freshwater Nematoda : Mr. Omer Cooper's Investigation of the Abyssinian Freshwaters (Hugh Scott Expedition).

MARION A. HAMILTON, B.Sc., Ph.D.

The Morphology and Biology of *Nepa cinerea* (Linn.) (Rhynchota)

ROBERT BROOM, D.Sc., F.R.S., C.M.Z.S.

On the *Pygocephalus*-like Crustacean of the South African Dwyka.

B. W. TUCKER, M.A., F.Z.S.

- (1) Note on a Skull of *Sus gargantea* Miller, in the Cambridge Museum.
- (2) On the Occurrence of *Rana graeca* at small Altitudes in the Naples District, with some Observations on Habits.

MALCOLM A. SMITH, M.R.C.S., L.R.C.P., F.Z.S.

Description of a new Genus of Sea-Snakes from the Coast of Australia, with a Note on the Structures providing for complete Closure of the Mouth in Aquatic Snakes.

PERCY ROYCHOFF LOWE, B.A., M.B., F.Z.S.

On the Anatomy of *Pseudocalyptomena* and the Occurrence of Broadbills (Eurylæmidæ) in Africa.

DAVID L. BRYCE, F.R.S.E., F.Z.S.

Report on the Rotifera : Mr. Omer-Cooper's Investigations of the Abyssinian Freshwaters (Dr. Hugh Scott Expedition).

R. BIGALKE, M.A., Ph.D.; F.Z.S.

Note on the Egg of the Nile Crocodile (*Orocodylus niloticus laurenti*).

R. ANTHONY, C.M.Z.S.

Vestiges de deux remplacements successifs de la 3ème molaire de lait chez l'Elephant d'Asie (*Elephas indicus* Linn.).

D. AUBERTIN, M.Sc., F.L.S.

Revision of the Genus *Hemipyrellia* Tns. (Diptera, Calliphoridae).

S. ZUCKERMAN, M.A., M.R.C.S., L.R.C.P.

The Menstrual Cycle in the Primates. III.—Breeding of the Chacma Baboon, *Papio porcarius*, with a Discussion on the Question of the Breeding of other Old-World Primates.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great cost of paper and printing. Papers should be condensed, and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

Secretary, Zool. Soc.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
February 10th, 1931.

No. 381.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

February 17th, 1931.

SIR ARTHUR SMITH WOODWARD, F.R.S., Vice-President,
in the Chair.

THE SECRETARY read a Report on the Additions to the Society's Menagerie during the month of January, 1931.

Prof. G. ELLIOT SMITH, F.R.S., F.Z.S., exhibited, and made remarks upon, a series of casts and photographs of the bones of the Peking Skull (*Sinanthropus*).

Prof. RAYMOND DART exhibited, and made remarks upon, the actual fossil remains of *Australopithecus*.

In the absence of the Authors, the following papers were taken as read:—H. C. WILKIE, F.R.C.V.S., F.R.M.S., F.Z.S., "The Middle Ear of the Horse (*Equus caballus*)"; M. K. SEREBRENNIKOV, "On the Polychromatism and Albinism of the Siberian Squirrels"; W. S. BRISTOWE, B.A., F.Z.S., (1) "A Contribution to the Knowledge of the Spider Fauna of South-West Ireland, and in particular the Islands off the Coast," (2) "The Spiders of the Island of Grassholm, and some Additions to the Skomer Island List"; A. B. MISRA, D.Sc., F.Z.S., "On the Internal Anatomy of the Female Lac Insect, *Laecifer lacea* Kerr. (Homoptera: Coccidae)."

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The next Meeting of the Society for Scientific Business will be held on Tuesday, March 3rd, 1931, at 5.30 P.M., when the following Communications will be made.—

S. ZUCKERMAN, M.A., M.R.C.S., L.R.C.P.

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R. BIGALKE, M.A., Ph.D., F.Z.S.

Note on the Egg of the Nile Crocodile (*Crocodylus niloticus*).

R. ANTHONY, C.M.Z.S.

Vestiges de deux remplacements successifs de la 3^{ème} molaire de lait chez l'Éléphant d'Asie (*Elephas indicus* Linn.).

D. AUBERTIN, M.Sc., F.L.S.

Revision of the Genus *Hemypyrellia* Tns. (Diptera : Balliphoridæ).

W. E. LE GROS CLARK, D.Sc., F.R.C.S., F.Z.S.

The Brain of *Microcebus murinus*.

MAURICE BURTON, M.Sc., F.Z.S.

The Interpretation of the Embryonic and Post-larval Characters of certain Tetraxonid Sponges, with Observations on Post-larval Growth-stages in some Species.

Prof. SYUTI T. ISSIKI.

On the Morphology and Systematics of Micropterygidæ (Lepidoptera Homoneura) of Japan and Formosa, with Considerations on the Australian, European, and North American Forms.

Dr. C. J. VAN DER KLAUW.

On the Tympanic Region of the Skull in the Mylodontinæ.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great cost of paper and printing. Papers should be condensed, and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

Secretary Zool. Soc.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.

February 24th, 1931.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

March 3rd, 1931.

Prof. E. W. MACBRIDE, M.A., F.R.S., Vice-President,
in the Chair.

Major S. S. FLOWER, O.B.E., F.Z.S., exhibited, and made remarks upon, a piece of wire which while charged with 220 volts alternating electric current was gnawed by a House-Mouse (*Mus musculus*).

Dr. MALCOLM A. SMITH, F.Z.S., gave a *résumé* of his paper "Description of a new Genus of Sea-Snakes from the Coast of Australia, with a Note on the Structures providing for complete Closure of the Mouth in Aquatic Snakes."

Major STANLEY S. FLOWER, O.B.E., F.Z.S., communicated his paper "Contributions to our Knowledge of the Duration of Life in Vertebrate Animals.—V. Mammals."

Dr. S. ZUCKERMAN, M.A., M.R.C.S., L.R.C.P., communicated his paper on "The Menstrual Cycle in the Primates.—III. The alleged Breeding Season of the Primates, with special reference to the Chacma Baboon (*Papio porcarius*)."

* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W. 8, on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

Major S. S. FLOWER, O.B.E., F.Z.S., gave a *résumé* of Mr. ELLIS LE G. TROUGHTON's paper on "The Occurrence of a Male and Female *Grampus griseus* (Delphinidæ) at Sydney, New South Wales."

In the absence of the Authors, the following Papers were taken as read:—Dr. ERNST SCHWARZ, "A Revision of the Genera and Species of Madagascar Lemuridæ"; WILLIAM J. DAKIN, D.Sc., F.Z.S., "The Osmotic Concentration of the Blood of *Callorhynchus millis* and *Epiceratodus forsteri* and the Significance of the Physico-chemical Condition of the Blood in regard to the Systematic Position of the Holocephali and the Dipnoi"; The Rev. E. J. PEARCE, M.A., F.E.S. "Report on the Halipidæ (Coleoptera): Mr. Omer Cooper's Investigation of the Abyssinian Freshwaters (Hugh Scott Expedition)."

The next Meeting of the Society for Scientific Business will be held on Tuesday, March 17th, 1931, at 5.30 P.M., when the following Communications will be made:—

ROBERT BROOM, D.Sc., F.R.S., C.M.Z.S.

On the *Pygocephalus*-like Crustacean of the South African Dwyka.

PERCY ROYCELOTT LOWE, B.A., M.B., F.Z.S.

On the Anatomy of *Pseudocalyptomena* and the Occurrence of Broadbills (Eurylaimidæ) in Africa.

J. ST. LEGER.

A Key to the Families and Genera of African Rodentia.

B. W. TUCKER, M.A., F.Z.S.

- (1) Note on a Skull of *Sus gargantea* Miller in the Cambridge Museum.
- (2) On the Occurrence of *Rana graeca* at small Altitudes in the Naples District, with some Observations on Habits.

I. A. R. I. 75*

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